41/937664

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

MADAN, Paul, S.
Madan, Mossman & Sriram, P.C.
2603 Augusta, Suite 700
Houston, Texas 77057
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year) 30 October 2000 (30.10.00)	
Applicant's or agent's file reference 14737.739.02	**IMPORTANT NOTIFICATION**
International application No. PCT/US00/07310	**International filing date** (day/month/year) 17 March 2000 (17.03.00)

1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
BALDERUS, James Poughkeepsie, NY United States of America	US	US
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
BALDERES, Demetrios Poughkeepsie, NY United States of America	US	US
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Athina Nickitas-Etienne Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

MADAN, Paul, S.
Madan, Mossman & Sriram, P.C.
2603 Augusta, Suite 700
Houston, Texas 77057
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year) 30 October 2000 (30.10.00)	
Applicant's or agent's file reference 14737.739.02	**IMPORTANT NOTIFICATION**
International application No. PCT/US00/07310	**International filing date** (day/month/year) 17 March 2000 (17.03.00)

1. The following indications appeared on record concerning:

☐ the applicant ☐ the inventor ☒ the agent ☐ the common representative

Name and Address	State of Nationality	State of Residence
MCCOMBS, David, L. Haynes and Boone, LLP Suite 4300 1000 Louisiana St. Houston, TX 77002 United States of America		
	Telephone No. 214-651-5000	
	Facsimile No. 214-651-5940	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☒ the person ☒ the name ☒ the address ☐ the nationality ☐ the residence

Name and Address	State of Nationality	State of Residence
MADAN, Paul, S. Madan, Mossman & Sriram, P.C. 2603 Augusta, Suite 700 Houston, Texas 77057 United States of America		
	Telephone No. 713 266 1130	
	Facsimile No. 713 266 8510	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☒ the receiving Office
☐ the International Searching Authority
☐ the International Preliminary Examining Authority
☒ the designated Offices concerned
☐ the elected Offices concerned
☒ other: MCCOMBS, David, L.

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Athina Nickitas-Etienne
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 08 January 2001 (08.01.01)	
International application No. PCT/US00/07310	**Applicant's or agent's file reference** 14737.739.02
International filing date (day/month/year) 17 March 2000 (17.03.00)	**Priority date** (day/month/year) 17 March 1999 (17.03.99)
Applicant RUSHEFSKY, Larry et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

13 October 2000 (13.10.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Athina Nickitas-Etienne Telephone No.: (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only
International Application No.
International Filing Date
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* **14737.739.02**

Box No. I TITLE OF INVENTION

INTEGRATED SENSOR PACKAGING AND MULTI-AXIS SENSOR ASSEMBLY PACKAGING

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

INPUT/OUTPUT, INC.
12300 Charles E. Selecman Drive
Suite 200
Stafford, Texas 77477
United States of America

☐ This person is also inventor.

Telephone No. 281-933-3339

Facsimile No. 281-552-3157

Teleprinter No.

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

RUSHEFSKY, Larry

Sugar Land, Texas
United States of America

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

McCOMBS, David L.; KICE, Warren B.; BECKER, Jeffrey M.; BELL, James R.; BUSH, Michael S.; COLSON, Randall E.; DAVIS, JR., Michael A.; DeLEON, Ruben C.; HEADLEY, Tim; IRANI, Rita M.; BALCONI-LAMICA, Michael; MATTINGLY, Todd; O'DELL, David M.; SARFATIS, Brandi W.; SIMMONS, David O.; Haynes and Boone, LLP, 1000 Louisiana St., Ste 4300, Houston, Texas 77002, UNITED STATES OF AMERICA

Telephone No. 713-547-2000

Facsimile No. 713-547-2600

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. 02

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SIGMAR, Axel
44 Glen Lock Court
Sugar Land, Texas 77478
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: **US**

State *(that is, country)* of residence: **US**

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

GOLDBERG, Howard D.
3007 Colony Crossing
Sugar Land, Texas 77479
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: **US**

State *(that is, country)* of residence: **US**

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

STALNAKER, W. Marc
4771 Sweetwated Boulevard PMB163
Sugar Land, Texas 77479
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: **US**

State *(that is, country)* of residence: **US**

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

RINNE, Ray

Raleigh, North Carolina
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: **US**

State *(that is, country)* of residence: **US**

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Sheet No. . . 03 . .

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

BALDERUS, James (Demetrios Balderes

Poughkeepsie, New York
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

LEMKE, Al

Hopewell Jct., New York
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

IP, Matthew
6401 DANVERS Court
Austin, Texas 78739
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

BEHN, Lawrence P.
1011 Crossroads Drive
Houston, Texas 77079
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Sheet No. 04 . . .

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

DOMAGALSKI, Klaus

Katy, Texas
United States of America

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence: US

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

YU, Lianzhong
5010 Grove West Boulevard, #605
Stafford, Texas 77477
United States of America

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: CN

State *(that is, country)* of residence: US

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SELVAKUMAR, Arjun
4436 Jim West
Bellaire, Texas 77401
United States of America

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: IN

State *(that is, country)* of residence: US

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Yu, Duli
15700 Lexington Boulevard, #1301
Sugar Land, Texas 77478
United States of America

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: CN

State *(that is, country)* of residence: US

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [x] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Sheet No. 05

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MARSH, James L.
3305 Shimmering Dawn
San Antonio, Texas 78253
United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MAXWELL, Peter

Houston, Texas
United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MORGAN, David

Richardson, Texas
United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

BUIE, Thomas
1716 Yorkshire
Richardson, Texas 75082
United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Continuation of Box No. III **FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

FABER, Kees

Voorhout
The Netherlands

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: NL

State *(that is, country)* of residence: NL

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ALTMAN, Sjoerd

Zoetermeer
The Netherlands

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: NL

State *(that is, country)* of residence: NL

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

LAROO, Richard

Lisse
The Netherlands

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence: NL

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

☒ **AP** **ARIPO Patent: GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA** **Eurasian Patent: AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent: AT** Austria, **BE** Belgium, **CH** and **LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent: BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* ....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*

☒ **AE** United Arab Emirates
☒ **AL** Albania ....
☒ **AM** Armenia ....
☒ **AT** Austria ....
☒ **AU** Australia ....
☒ **AZ** Azerbaijan
☒ **BA** Bosnia and Herzegovina ....
☒ **BB** Barbados
☒ **BG** Bulgaria ....
☒ **BR** Brazil ....
☒ **BY** Belarus ....
☒ **CA** Canada
☒ **CH and LI** Switzerland and Liechtenstein
☒ **CN** China ....
☒ **CR** Costa Rica ....
☒ **CU** Cuba ....
☒ **CZ** Czech Republic ....
☒ **DE** Germany ....
☒ **DK** Denmark ....
☒ **DM** Dominica
☒ **EE** Estonia ....
☒ **ES** Spain ....
☒ **FI** Finland ....
☒ **GB** United Kingdom
☒ **GD** Grenada
☒ **GE** Georgia ....
☒ **GH** Ghana ....
☒ **GM** Gambia
☒ **HR** Croatia ....
☒ **HU** Hungary ....
☒ **ID** Indonesia
☒ **IL** Israel ....
☒ **IN** India ....
☒ **IS** Iceland
☒ **JP** Japan ....
☒ **KE** Kenya ....
☒ **KG** Kyrgyzstan ....
☒ **KP** Democratic People's Republic of Korea ....
☒ **KR** Republic of Korea ....
☒ **KZ** Kazakhstan ....
☒ **LC** Saint Lucia
☒ **LK** Sri Lanka
☒ **LR** Liberia
☒ **LS** Lesotho ....
☒ **LT** Lithuania
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☒ **LV** Latvia
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Sheet No. 08

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

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(71) Applicant (*for all designated States except US*): INPUT/OUTPUT, INC. [US/US]; Suite 200, 12300 Charles E. Selecman Drive, Stafford, TX 77477 (US).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): RUSHEFSKY, Larry [US/US]; Sugar Land, TX (US). SIGMAR, Axel [US/US]; 44 Glen Lock Court, Sugar Land, TX 77478 (US). GOLDBERG, Howard, D. [US/US]; 3007 Colony Crossing, Sugar Land, TX 77479 (US). STALNAKER, W., Marc [US/US]; 4771 Sweetwated Boulevard PMB163, Sugar Land, TX 77479 (US). RINNE, Ray [US/US]; Raleigh, NC (US). BALDERUS, James [US/US]; Poughkeepsie, NY (US). LEMKE, Al [US/US]; Hopewell Jct., NY (US). IP, Matthew [–/US]; Austin, TX (US). BEHN, Lawrence, P. [US/US]; 1011 Crossroads Drive, Houston, TX 77079 (US). DOMAGALSKI, Klaus [–/US]; Katy, TX (US). YU, Lianzhong [CN/US]; 5010 Grove West Boulevard #605, Stafford, TX 77477 (US). SELVAKUMAR, Arjun [IN/US]; 4436 Jim West, Bellaire, TX 77401 (US). YU, Duli [CN/US]; 15700 Lexington Boulevard #1301, Sugar Land, TX 77478 (US). MARSH, James, L. [US/US]; 3305 Shimmering Dawn, San Antonio, TX 78253 (US). MAXWELL, Peter [US/US]; Houston, TX (US). MORGAN, David [US/US]; Richardson, TX 75082 (US). BUIE, Thomas [US/US]; 1716 Yorkshire, Richardson, TX 75082 (US). FABER, Kees [NL/NL]; Voorhout (NL). ALTMAN, Sjoerd [NL/NL]; Zoetermeer (NL). LAROO, Richard [–/NL]; Lisse (NL).

(74) Agents: MCCOMBS, David, L. et al.; Haynes and Boone, LLP, Suite 4300, 1000 Louisiana St., Houston, TX 77002 (US).

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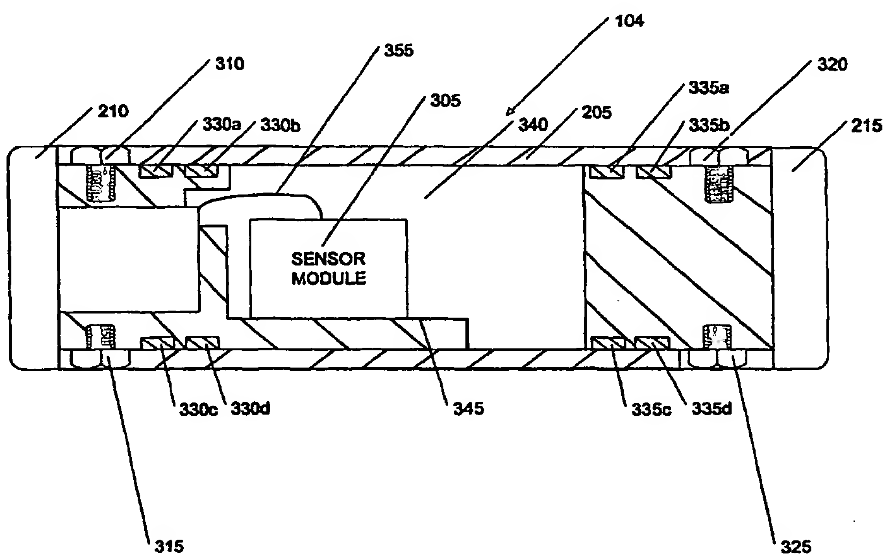
(54) Title: INTEGRATED AND MULTI-AXIS SENSOR ASSEMBLY AND PACKAGING



(57) Abstract

A sensor apparatus (104) includes a plural different spatial direction axis of sensitivity positioned sensor package containing sensor module (305) supported by a planar surface (345) within a cavity (340) of a housing (205) coupled to a first end cap (210) by a PC–board connection (355). Housing (205) is further coupled to first end cap (210) by a first coupling member (315) and a second coupling member (320) and is also coupled to an opposite second end cap (215) by a third coupling member (320) and a fourth coupling member (325). Interface sealing members (330a, 330b, 330c, 330d) seal between housing (205) and first end cap (210). Interface sealing members (335a, 335b, 335c, 335d) seal between housing (205) and second end cap (215).

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INTEGRATED AND MULTI–AXIS SENSOR ASSEMBLY AND PACKAGING

Background of the Invention

The present disclosure relates generally to the packaging of a sensor assembly, and in particular to packaging a multi-axis sensor assembly.

In packaging a multi-axis sensor assembly, high vector fidelity and low cross-axis sensitivity between the three major axes (x-axis, y-axis, and z-axis) is generally required. Orthogonally mounting three single-axis sensors typically results in low vector fidelity and high cross-axis sensitivity. There are also numerous manufacturing steps.

The present invention is directed at creating a multi-axis sensor package that has high vector fidelity, low cross-axis sensitivity, and a minimum number of manufacturing steps.

Summary of the Invention

According to one aspect of the invention, an apparatus is provided that includes a housing, a plurality of end caps, a sensor module, a plurality of sealing members, and a plurality of coupling members.

According to another aspect of the invention, an apparatus is provided that includes a housing, a sensor, a lid assembly, and a controller assembly.

According to another aspect of the invention, an apparatus is provided that includes a plurality of sensor packages, each sensor package having an axis of sensitivity positioned in a different spatial direction.

According to another aspect of the invention, a method of coupling a controller to a housing is provided that includes dispensing an adhesive on the housing, placing the controller on the housing, curing the adhesive, wire-bonding the controller to the housing, encapsulating the controller and wire-bonds, and curing the encapsulant.

According to another aspect of the invention, a method of assembling a sensor package including of a housing, a sensor, a controller, and a lid assembly is provided that includes coupling the sensor to the housing, coupling the lid assembly to the housing, and coupling the controller to the housing.

According to another aspect of the invention, a method of assembling a multi-axis sensor assembly is provided that includes a plurality of sensor packages, each sensor package having an axis of sensitivity positioned in a different spatial direction.

According to another aspect of the invention, a sensor package is provided that includes a substrate including a slot and a sensor positioned within the slot.

According to another aspect of the invention, a method of assembling a sensor package is provided that includes a substrate and a sensor, including coupling the sensor to the substrate.

Brief Description of the Drawings

Fig. 1 is a schematic view illustrating an embodiment of a system for sensor measurement.

Fig. 2 is a schematic view of an embodiment of the sensor apparatus of the system of Fig. 1.

Fig. 3 is a cross-sectional view of an embodiment of the sensor apparatus of Fig. 2.

Fig. 4 is a schematic view of an embodiment of the sensor module of Fig. 3.

Fig. 5A is a schematic view of an embodiment of the sensor package of Fig. 4.

Fig. 5B is a cross-sectional view of an embodiment of the sensor package of Fig. 5A.

Fig. 5C is a top view of an embodiment of the housing of the sensor package of Fig. 5A without the sensor or lid assembly.

Fig. 5D is a side view of an embodiment of the housing of the sensor package of Fig. 5A.

Fig. 5E is a bottom view of an embodiment of the housing of the sensor package of Fig. 5A.

Fig. 5F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 5A.

Fig. 5G is a top view of an embodiment of the resilient couplings of the sensor package of Fig. 5A.

Fig. 5H is a detailed view of an embodiment of the resilient couplings of the sensor package of Fig. 5A.

Fig. 5I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 5A.

Fig. 5J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 5A.

Fig. 5K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 5A.

Fig. 5L is top view of an embodiment of the solder preform of the sensor package of Fig. 5A.

Fig. 5M is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5N is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5O is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5P is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5Q is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5R is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5S is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5T is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5U is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 5A.

Fig. 5V is a top view of an alternate embodiment of the resilient couplings of the sensor package of Fig. 5A.

Fig. 5W is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 5A.

Fig. 5X is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 5A.

Fig. 5Y is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 5A.

Fig. 6A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 6B is a cross-sectional view of an embodiment of the sensor package of Fig. 6A.

Fig. 6C is a top view of the housing of an embodiment of the sensor package of Fig. 6A. without the sensor or lid assembly.

Fig. 6D is a side view of an embodiment of the housing of the sensor package of Fig. 6A.

Fig. 6E is a bottom view of an embodiment of the housing of the sensor package of Fig. 6A.

Fig. 6F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 6A.

Fig. 6G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 6A.

Fig. 6H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 6A.

Fig. 6I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 6A.

Fig. 6J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 6A.

Fig. 6K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 6A.

Fig. 6L is top view of an embodiment of the solder preform of the sensor package of Fig. 6A.

Fig. 7A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 7B is a cross-sectional view of an embodiment of the sensor package of Fig. 7A.

Fig. 7C is a top view of the housing of an embodiment of the sensor package of Fig. 7A. without the sensor or lid assembly.

Fig. 7D is a side view of the housing of an embodiment of the sensor package of Fig. 7A.

Fig. 7E is a bottom view of an embodiment of the housing of the sensor package of Fig. 7A.

Fig. 7F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 7A.

Fig. 7G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 7A.

Fig. 7H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 7A.

Fig. 7I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 7A.

Fig. 7J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 7A.

Fig. 7K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 7A.

Fig. 7L is top view of an embodiment of the solder preform of the sensor package of Fig. 7A.

Fig. 8A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 8B is a cross-sectional view of an embodiment of the sensor package of Fig. 8A.

Fig. 8C is a top view of the housing of an embodiment of the sensor package of Fig. 8A. without the sensor or lid assembly.

Fig. 8D is a side view of an embodiment of the housing of the sensor package of Fig. 8A.

Fig. 8E is a bottom view of an embodiment of the housing of the sensor package of Fig. 8A.

Fig. 8F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 8A.

Fig. 8G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 8A.

Fig. 8H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 8A.

Fig. 8I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 8A.

Fig. 8J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 8A.

Fig. 8K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 8A.

Fig. 8L is top view of an embodiment of the solder preform of the sensor package of Fig. 8A.

Fig. 9A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 9B is a cross-sectional view of an embodiment of the sensor package of Fig. 9A.

Fig. 9C is a top view of the housing of an embodiment of the sensor package of Fig. 9A. without the sensor or lid assembly.

Fig. 9D is a side view of the housing of an embodiment of the sensor package of Fig. 9A.

Fig. 9E is a bottom view of an embodiment of the housing of the sensor package of Fig. 9A.

Fig. 9F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 9A.

Fig. 9G is a top view of an embodiment of the first resilient coupling of the sensor package of Fig. 9A.

Fig. 9H is a detailed view of an embodiment of the first resilient coupling of the sensor package of Fig. 9A.

Fig. 9I is a top view of an embodiment of the second resilient coupling of the sensor package of Fig. 9A.

Fig. 9J is a detailed view of an embodiment of the second resilient coupling of the sensor package of Fig. 9A.

Fig. 9K is a top view of an embodiment of the sliding supports of the sensor package of Fig. 9A.

Fig. 9L is a side view of an embodiment of the lid assembly of the sensor package of Fig. 9A.

Fig. 9M is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 9A.

Fig. 9N is top view of an embodiment of the solder preform of the sensor package of Fig. 9A.

Fig. 9O is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9P is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9Q is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9R is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9S is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9T is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9U is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9V is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9W is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 9A.

Fig. 9X is a top view of an alternate embodiment of the resilient couplings of the sensor package of Fig. 9A.

Fig. 9Y is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 9A.

Fig. 9Z is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 9A.

Fig. 9AA is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 9A.

Fig. 10A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 10B is a cross-sectional view of an embodiment of the sensor package of Fig. 10A.

Fig. 10C is a top view of an embodiment of the housing of the sensor package of Fig. 10A. without the sensor or lid assembly.

Fig. 10D is a side view of an embodiment of the housing of the sensor package of Fig. 10A.

Fig. 10E is a bottom view of an embodiment of the housing of the sensor package of Fig. 10A.

Fig. 10F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 10A.

Fig. 10G is a top view of an embodiment of the first resilient coupling of the sensor package of Fig. 10A.

Fig. 10H is a detailed view of an embodiment of the first resilient coupling of the sensor package of Fig. 10A.

Fig. 10I is a top view of an embodiment of the second resilient coupling of the sensor package of Fig. 10A.

Fig. 10J is a detailed view of an embodiment of the second resilient coupling of the sensor package of Fig. 10A.

Fig. 10K is a top view of an embodiment of the sliding supports of the sensor package of Fig. 10A.

Fig. 10L is a side view of an embodiment of the lid assembly of the sensor package of Fig. 10A.

Fig. 10M is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 10A.

Fig. 10N is top view of an embodiment of the solder preform of the sensor package of Fig. 10A.

Fig. 11A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 11B is a cross-sectional view of an embodiment of the sensor package of Fig. 11A.

Fig. 11C is a top view of an embodiment of the housing of the sensor package of Fig. 11A. without the sensor or lid assembly.

Fig. 11D is a side view of an embodiment of the housing of the sensor package of Fig. 11A.

Fig. 11E is a bottom view of an embodiment of the housing of the sensor package of Fig. 11A.

Fig. 11F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 11A.

Fig. 11G is a top view of an embodiment of the first resilient coupling of the sensor package of Fig. 11A.

Fig. 11H is a detailed view of an embodiment of the first resilient coupling of the sensor package of Fig. 11A.

Fig. 11I is a top view of an embodiment of the second resilient coupling of the sensor package of Fig. 11A.

Fig. 11J is a detailed view of an embodiment of the second resilient coupling of the sensor package of Fig. 11A.

Fig. 11K is a top view of an embodiment of the sliding supports of the sensor package of Fig. 11A.

Fig. 11L is a side view of an embodiment of the lid assembly of the sensor package of Fig. 11A.

Fig. 11M is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 11A.

Fig. 11N is top view of an embodiment of the solder preform of the sensor package of Fig. 11A.

Fig. 12A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 12B is a cross-sectional view of an embodiment of the sensor package of Fig. 12A.

Fig. 12C is a top view of an embodiment of the housing of the sensor package of Fig. 12A. without the sensor or lid assembly.

Fig. 12D is a side view of an embodiment of the housing of the sensor package of Fig. 12A.

Fig. 12E is a bottom view of an embodiment of the housing of the sensor package of Fig. 12A.

Fig. 12F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 12A.

Fig. 12G is a top view of an embodiment of the first resilient coupling of the sensor package of Fig. 12A.

Fig. 12H is a detailed view of an embodiment of the first resilient coupling of the sensor package of Fig. 12A.

Fig. 12I is a top view of an embodiment of the second resilient coupling of the sensor package of Fig. 12A.

Fig. 12J is a detailed view of an embodiment of the second resilient coupling of the sensor package of Fig. 12A.

Fig. 12K is a top view of an embodiment of the sliding supports of the sensor package of Fig. 12A.

Fig. 12L is a side view of an embodiment of the lid assembly of the sensor package of Fig. 12A.

Fig. 12M is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 12A.

Fig. 12N is top view of an embodiment of the solder preform of the sensor package of Fig. 12A.

Fig. 13A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 13B is a cross-sectional view of an embodiment of the sensor package of Fig. 13A.

Fig. 13C is a top view of an embodiment of the housing of the sensor package of Fig. 13A. without the sensor or lid assembly.

Fig. 13D is a side view of an embodiment of the housing of the sensor package of Fig. 13A.

Fig. 13E is a bottom view of an embodiment of the housing of the sensor package of Fig. 13A.

Fig. 13F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 13A.

Fig. 13G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 13A.

Fig. 13H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 13A.

Fig. 13I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 13A.

Fig. 13J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 13A.

Fig. 13K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 13A.

Fig. 13L is top view of an embodiment of the solder preform of the sensor package of Fig. 13A.

Fig. 13M is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 13A.

Fig. 13N is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 13A.

Fig. 13O is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 13A.

Fig. 13P is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 13A.

Fig. 13Q is a top view of an alternate embodiment of the bond pad of the sensor package of Fig. 13A.

Fig. 13V is a top view of an alternate embodiment of the resilient couplings of the sensor package of Fig. 13A.

Fig. 13W is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 13A.

Fig. 13X is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 13A.

Fig. 13Y is a top view of an alternate embodiment of the sliding supports of the sensor package of Fig. 13A.

Fig. 14A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 14B is a cross-sectional view of an embodiment of the sensor package of Fig. 14A.

Fig. 14C is a top view of an embodiment of the housing of the sensor package of Fig. 14A. without the sensor or lid.

Fig. 14D is a side view of an embodiment of the housing of the sensor package of Fig. 14A.

Fig. 14E is a bottom view of an embodiment of the housing of the sensor package of Fig. 14A.

Fig. 14F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 14A.

Fig. 14G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 14A.

Fig. 14H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 14A.

Fig. 14I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 14A.

Fig. 14J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 14A.

Fig. 14K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 14A.

Fig. 14L is top view of an embodiment of the solder preform of the sensor package of Fig. 14A.

Fig. 15A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 15B is a cross-sectional view of an embodiment of the sensor package of Fig. 15A.

Fig. 15C is a top view of an embodiment of the housing of the sensor package of Fig. 15A. without the sensor or lid.

Fig. 15D is a side view of an embodiment of the housing of the sensor package of Fig. 15A.

Fig. 15E is a bottom view of an embodiment of the housing of the sensor package of Fig. 15A.

Fig. 15F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 15A.

Fig. 15G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 15A.

Fig. 15H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 15A.

Fig. 15I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 15A.

Fig. 15J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 15A.

Fig. 15K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 15A.

Fig. 15L is top view of an embodiment of the solder preform of the sensor package of Fig. 15A.

Fig. 16A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 16B is a cross-sectional view of an embodiment of the sensor package of Fig. 16A.

Fig. 16C is a top view of an embodiment of the housing of the sensor package of Fig. 16A. without the sensor or lid.

Fig. 16D is a side view of an embodiment of the housing of the sensor package of Fig. 16A.

Fig. 16E is a bottom view of an embodiment of the housing of the sensor package of Fig. 16A.

Fig. 16F is a bottom view of an embodiment of the sensor of the sensor package of Fig. 16A.

Fig. 16G is a top view of an embodiment of the resilient coupling of the sensor package of Fig. 16A.

Fig. 16H is a detailed view of an embodiment of the resilient coupling of the sensor package of Fig. 16A.

Fig. 16I is a top view of an embodiment of the sliding supports of the sensor package of Fig. 16A.

Fig. 16J is a side view of an embodiment of the lid assembly of the sensor package of Fig. 16A.

Fig. 16K is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 16A.

Fig. 16L is top view of an embodiment of the solder preform of the sensor package of Fig. 16A.

Fig. 17A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 17B is a cross-sectional view of an embodiment of the sensor package of Fig. 17A.

Fig. 17C is a top view of an embodiment of the housing of the sensor package of Fig. 17A. without the sensor or lid assembly.

Fig. 17D is a side view of an embodiment of the housing of the sensor package of Fig. 17A.

Fig. 17E is a bottom view of an embodiment of the housing of the sensor package of Fig. 17A.

Fig. 17F is a schematic view of an embodiment of the spring assembly of the sensor package of Fig. 17A.

Fig. 17G is a schematic view of an embodiment of the shorting clip of the sensor package of Fig. 17A.

Fig. 17H is a side view of an embodiment of the lid assembly of the sensor package of Fig. 17A.

Fig. 17I is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 17A.

Fig. 17J is top view of an embodiment of the solder preform of the sensor package of Fig. 17A.

Fig. 18A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 18B is a cross-sectional view of an embodiment of the sensor package of Fig. 18A.

Fig. 18C is a top view of an embodiment of the housing of the sensor package of Fig. 18A. without the sensor or lid assembly.

Fig. 18D is a side view of an embodiment of the housing of the sensor package of Fig. 18A.

Fig. 18E is a bottom view of an embodiment of the housing of the sensor package of Fig. 18A.

Fig. 18F is a schematic view of an embodiment of the spring assembly of the sensor package of Fig. 18A.

Fig. 18G is a schematic view of an embodiment of the shorting clip of the sensor package of Fig. 18A.

Fig. 18H is a side view of an embodiment of the lid assembly of the sensor package of Fig. 18A.

Fig. 18I is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 18A.

Fig. 18J is top view of an embodiment of the solder preform of the sensor package of Fig. 18A.

Fig. 19 is a schematic view of an alternate embodiment of the sensor module of Fig. 3.

Fig. 20 is a schematic view of an alternate embodiment of the sensor module of Fig. 3.

Fig. 21A is a cross-sectional view of an alternate embodiment of the sensor package of Fig. 4 before coupling.

Fig. 21B is a top view of an embodiment of the sensor package of Fig. 21A.

Fig. 21C is a cross-sectional view of an embodiment of the sensor package of Fig. 21A after coupling.

Fig. 21D is a cross-sectional view of an alternate embodiment of the sensor package of Fig. 21A.

Fig. 22A is a top view of an alternate embodiment of the apparatus of Fig. 5B.

Fig. 22B is a cross-sectional view of the apparatus of Fig. 22A.

Fig. 22C is a top view of an alternate embodiment of the apparatus of Fig. 5B.

Fig. 22D is a cross-sectional view of the apparatus of Fig. 22C.

Fig. 23A is a top view of an alternate embodiment of the sensor module of Fig. 3.

Fig. 23B is a cross-sectional view of an alternate embodiment of the sensor module of Fig. 23A.

Fig. 24 is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 25A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 25B is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 26A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 26B is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 27A is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Fig. 27B is a schematic view of an alternate embodiment of the sensor package of Fig. 4.

Detailed Description of the Illustrative Embodiments

Referring initially to Fig. 1, an embodiment of a system 100 for recording seismic information preferably includes a controller 102 and a sensor apparatus 104.

The controller 102 monitors and controls the system 100. The controller 102 preferably receives data from the sensor apparatus 104. The controller 102 preferably monitors the sensor apparatus 104. The controller 102 is coupled to the sensor apparatus 104 by electrical connections. The controller 102 may be any number of conventional commercially available controllers, for example, of the type integrated circuit chips. In a preferred embodiment, the controller 102 is an application specific integrated chip in order to optimally provide readout and control of the sensor.

In a preferred embodiment, the sensor apparatus 104 ranges from about 0.75 inches to 1 inch in diameter in order to optimally provide minimum cross-sectional area. In a preferred embodiment, the sensor apparatus 104 is waterproof and pressure-proof in order to optimally provide environmental protection.

Referring to Figs. 2 and 3, an embodiment of the sensor apparatus 104 preferably includes a housing 205, a first end cap 210, and a second end cap 215. The housing 205 is coupled to the first end cap 210, the second end cap 215 and a sensor module 305. The housing 205 is preferably coupled to the first end cap 210 by a first coupling member 310 and a second coupling member 315. The first coupling member 310 may, for example, be a mechanical fastener. In a preferred embodiment the first coupling member 310 is a mechanical fastener capable of being torqued to a predetermined position in order to optimally provide mechanical coupling. The second coupling member 315 may, for example, be a mechanical fastener. In a preferred embodiment the second coupling member 315 is a mechanical fastener capable of being torqued to a predetermined position in order to optimally provide mechanical coupling.

The housing 205 is preferably coupled to the second end cap 215 by a third coupling member 320 and a fourth coupling member 325. The third coupling member 320 may, for example, be a mechanical fastener. In a preferred embodiment the third coupling member 320 is a mechanical fastener capable of being torqued to a predetermined position in order to optimally provide mechanical coupling. The fourth coupling member 325 may, for example, be a mechanical fastener. In a preferred embodiment the fourth coupling member 325 is a mechanical fastener capable of being torqued to a predetermined position in order to optimally provide mechanical coupling.

One or more first sealing members 330 preferably seal the interface between the housing 205 and the first end cap 210. The first sealing members 330 may, for example, be elastomer rings. In a preferred embodiment, the first sealing members 330 are elastomer rings capable of being compressed to a predetermined position in order to optimally provide sealing. The number of first sealing members 330 preferably depend on the sealing requirements of the

interface between the housing 205 and the first end cap 210. In a preferred embodiment, there is a first sealing member 330a, a second first sealing member 330b, a third first sealing member 330c, and a fourth first sealing member 330d.

One or more second sealing members 335 preferably seal the interface between the housing 205 and the second end cap 215. The second sealing members 335 may, for example, be elastomer rings. In a preferred embodiment, the second sealing members 335 are elastomer rings capable of being compressed to a predetermined position in order to optimally provide sealing. The number of second sealing members 335 required preferably depend on the sealing requirements of the interface between the housing 205 and the second end cap 215. In a preferred embodiment, there is a first second sealing member 335a, a second sealing member 335b, a third second sealing member 335c, and a fourth second sealing member 335d.

The housing 205 preferably includes a cavity 340 and a planar surface 345. The housing 205 may, for example, be metal tubing. In a preferred embodiment, the housing 205 is a metal tube fabricated from high strength materials in order to optimally provide a robust pressure vessel.

The sensor module 305 is preferably supported by the planar surface 345 within the cavity 340 of the housing 205 and preferably coupled to the first end cap 210 by a PC-board connection 355.

In several alternate embodiments, the sensor module 305 may be used in a variety of sensor apparatuses 104, for example, geophone packages, inclinometers, inertial guidance systems, and vibration monitoring.

Referring to Fig. 4, the sensor module 305 preferably includes one or more sensor packages 405 and a substrate 410. The sensor packages 405 are preferably coupled to the substrate 410. In a preferred embodiment, the sensor module 305 includes a first sensor package 405a, a second sensor package 405b, and a third sensor package 405c. The first sensor package 405a preferably includes an axis of sensitivity 415. The axis of sensitivity 415 is preferably approximately parallel to the x-axis. The first sensor package 405a is preferably coupled to the substrate 410 to maintain the axis of sensitivity 415 parallel to the x-axis. The second sensor package 405b preferably includes an axis of sensitivity

420. The axis of sensitivity 420 is preferably approximately parallel to the y-axis. The second sensor package 405b is preferably coupled to the substrate 410 to maintain the axis of sensitivity 420 parallel to the y-axis. The third sensor package 405c preferably includes an axis of sensitivity 425. The axis of sensitivity 425 is preferably approximately parallel to the z-axis. The third sensor package 405c is preferably coupled to the substrate 410 to maintain the axis of sensitivity 425 parallel to the z-axis.

The sensor packages 405 may, for example, be coupled to the substrate 410 using one of the following methods: solder-paste surface mount, solder-ball, or leads. In a preferred embodiment, the sensor packages 405 are coupled to the substrate 410 by solder paste surface mount in order to optimally provide low profile components. The substrate 410 may, for example, be ceramic or organic PC-boards. In a preferred embodiment, the substrate 410 is ceramic PC-board in order to optimally provide high temperature capability.

Referring to Figs. 5A through 5L, an embodiment of the sensor package 405 preferably includes a housing 502, a sensor 504, a lid assembly 506, and a controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 502. The controller assembly 508 is preferably coupled to the bottom of the housing 502. The sensor 504 is preferably coupled within the housing 502.

The housing 502 is preferably coupled to the sensor 504, the lid assembly 506, the controller assembly 508, one or more electrical connections 510, one or more resilient couplings 512, and one or more sliding supports 514. The housing 502 preferably includes a cavity 516, one or more planar surfaces 518, one or more exterior surfaces 520, and a bottom exterior surface 522. The cavity 516 preferably includes a first wall 524, a second wall 526, a third wall 528 and a fourth wall 530. The first wall 524 and the third wall 528 are preferably approximately parallel to each other and the second wall 526 and the fourth wall 530 are preferably approximately parallel to each other. The second wall 526 and the fourth wall 530 are also preferably perpendicular to the first wall 524 and the third wall 528. The cavity 516 preferably includes a bottom surface 532. The bottom surface 532 may, for example, be ceramic. In a preferred embodiment,

the bottom surface 532 is gold plated in order to optimally provide solderability. The housing 502 may, for example, be any number of conventional commercially available housings of the type ceramic, plastic, or metal. In a preferred embodiment, the housing 502 is ceramic in order to optimally provide vacuum sealing capability.

The housing 502 preferably includes a first planar surface 518a, a second planar surface 518b, a third planar surface 518c, and a fourth planar surface 518d. The first planar surface 518a preferably includes one or more planar bond pads 534. The planar bond pads 534 are preferably approximately rectangularly shaped. The planar bond pads 534 may, for example, be used for solder paste, solder balls or leads attachment. In a preferred embodiment, the planar bond pads 534 are used to solder the sensor packages 405 to the substrate 410. The number of planar bond pads 534 preferably depend on having sufficient planar bond pads 534 to connect the controller assembly 508 to the housing 502. The second planar surface 518b may, for example, be plated with a metal. In a preferred embodiment, the second planar surface 518b is plated with gold in order to optimally provide solderability. The third planar surface 518c may, for example, be plated with a metal. In a preferred embodiment, the third planar surface 518c is plated with gold in order to optimally provide wire bonding. The fourth planar surface 518d may, for example, be plated with a metal. In a preferred embodiment, the fourth planar surface 518d is plated with gold in order to optimally provide wire bonding.

The housing 502 preferably includes a plurality of first exterior surfaces 520a and a plurality of second exterior surfaces 520b. In a preferred embodiment, there are four first exterior surfaces 520a and four second exterior surfaces 520b forming an approximate octagon. The second exterior surfaces 520b preferably couple the first exterior surfaces 520a to each other. The first exterior surfaces 520a preferably include one or more exterior bond pads 536. The exterior bond pads 536 are preferably approximately rectangularly shaped. The exterior bond pads 536 may, for example, be used for solder paste, solder ball or leads attachment. In a preferred embodiment, the exterior bond pads 536 are used to solder the sensor package 405 to the substrate 410. In an alternate

embodiment, the exterior bond pads 536 are on a single first exterior surface 520a.

The bottom exterior surface 522 of the housing 502 preferably includes a contact pad 538, one or more bond pads 540, and one or more connecting pads 542. The contact pad 538 may, for example, be plated with a metal. In a preferred embodiment, the contact pad 538 is gold-plated in order to optimally provide a reliable electrical connection. The planar bond pads 534 on the first planar surface 518a are preferably electrically coupled to the bond pads 540 on the bottom exterior surface 522 by electrical paths molded into the housing 502. The resilient couplings 512, the third planar surface 518c and the fourth planar surface 518d are preferably coupled to the bond pads 540 on the bottom exterior surface 522 by electrical paths molded into the housing 502. The bond pads 540 may, for example, be plated with a metal. In a preferred embodiment, the bond pads 540 are gold-plated in order to optimally provide wire bonding. The number of bond pads 540 preferably depend on having sufficient bond pads 540 to connect the controller assembly 508 to the housing 502. The connecting pads 542 preferably connect the contact pad 538 to the bond pads 540. The connecting pads 542 may, for example, be metal plated. In a preferred embodiment, the connecting pads 542 are gold-plated in order to optimally provide a conductive pathway between the contact pad 538 and the bond pads 540. In a preferred embodiment, there is a first connecting pad 542a and a second connecting pad 542b. The exterior bond pads 536 are preferably electrically connected to the bond pads 540 by electrical paths molded into the housing 502.

The sensor 504 is preferably resiliently attached to the housing 502 by the resilient couplings 512, slidingly supported by the sliding supports 514, and electrically coupled to the housing 502 by the electrical connections 510. The sensor 504 preferably has an approximately rectangular cross-sectional shape. The sensor 504 preferably has a passive region 566 at one end and an active region 588 at an opposite end. In a preferred embodiment, the sensor 504 includes a first member 544, a second member 546, and a third member 548. The first member 544 is preferably on top of the second member 546 and the

second member 546 is preferably on top of the third member 548. In a preferred embodiment, the first member 544, the second member 546, and the third member 548 are a micro machined sensor substantially as disclosed in copending U. S. Patent Application Serial No. _________, Attorney Docket No. 14737.737, filed on ____________, the contents of which are incorporated herein by reference.

The first member 544 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the first member includes a top parallel planar surface 550. The second member 546 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the second member 546 includes a middle parallel planar surface 552. The third member 548 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the third member 548 includes a bottom parallel planar surface 554.

The bottom parallel planar surface 554 of the sensor 504 preferably includes a first side 556, a second side 558, a third side 560, and a fourth side 562. The first side 556 and the third side 560 are preferably approximately parallel to each other and the second side 558 and the fourth side 562 are preferably approximately parallel to each other and preferably approximately perpendicular to the first side 556 and the third side 560.

In a preferred embodiment, the bottom parallel planar surface 554 of the sensor 504 includes one or more bond pads 564. In a preferred embodiment, the bond pads 564 are located in the passive region 566 of the bottom parallel planar surface 554 of the sensor 504. The bond pads 564 may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the first side 556 of the bottom parallel planar surface 554 of the sensor 504 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second side 558 of the bottom parallel planar surface 554 of the sensor 504. In a preferred embodiment, the bond pads 564 are located a perpendicular distance ranging from about 7 to 12 mils from the first side 556 of the bottom parallel planar surface 554 of the sensor 504 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 7 to 12 mils

from the second side 558 of the bottom parallel planar surface 554 of the sensor 504 in order to optimally minimize thermal stresses.

The bond pads 564 may, for example, be used for solder, conductive epoxy, non-conductive epoxy or glass frit bonding. In a preferred embodiment, the bond pads 564 are used for solder bonding in order to optimally provide good manufacturability. In a preferred embodiment, the bond pads 564 contact area is maximized in order to optimize the shock tolerance of the sensor 504. In a preferred embodiment, the bond pads 564 have minimal discontinuities in order to optimize the distribution of thermal stresses in the sensor 504. In several alternate embodiments, there are a plurality of bond pads 564 in order to optimize the relief of thermal stresses in the sensor 504. In a preferred embodiment, there is a single bond pad 564a. The bond pad 564a has an approximately rectangular cross-sectional shape. The length L_{564a} of the bond pad 564a may range, for example, from about 200 to 240 mils. In a preferred embodiment, the length L_{564a} of the bond pad 564a ranges from about 200 to 220 mils in order to optimally minimize thermal stresses. The width W_{564a} of the bond pad 564a may range, for example, from about 15 to 25 mils. In a preferred embodiment, the width W_{564a} of the bond pad 564a ranges from about 18 to 22 mils in order to optimally minimize thermal stresses. The height H_{564a} of the bond pad 564a may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564a} of the bond pad 564a ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

The resilient couplings 512 preferably resiliently attach the bond pads 564 to the housing 502. The resilient couplings 512 may electrically attach the sensor 504 to the housing 502. The resilient couplings 512 are preferably coupled to the bottom surface 532 of the cavity 516 of the housing 502. In a preferred embodiment, the resilient couplings 512 are solder preforms. In a preferred embodiment, the resilient couplings 512 have minimal discontinuities in order to optimize the distribution of thermal stresses in the sensor 504. In several alternate embodiments, there are a plurality of resilient couplings 512 in order to optimize the relief of thermal stresses in the sensor 504. In a preferred embodiment, the resilient couplings 512 have an approximate cross-sectional

rectangular shape. The resilient couplings 512 may, for example, be any number of conventional commercially available solder preforms of the type eutectic or non-eutectic. In a preferred embodiment, the resilient couplings 512 are a eutectic type in order to optimally provide good yield strength with a reasonable melt temperature. In a preferred embodiment, there is a single resilient coupling 512a.

The length L_{512a} of the resilient coupling 512a may range, for example, from about 200 to 250 mils. In a preferred embodiment, the length L_{512a} of the resilient coupling 512a ranges from about 225 to 235 mils in order to optimally minimize thermal stresses. The width W_{512a} of the resilient coupling 512a may range, for example, from about 20 to 35 mils. In a preferred embodiment, the width W_{512a} of the resilient coupling 512a ranges from about 25 to 30 mils in order to optimally minimize thermal stresses. The height H_{512} of the resilient coupling 512a may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{512} of the resilient coupling 512a ranges from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

The resilient couplings 512 may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the resilient couplings 512 are located a perpendicular distance ranging from about 7 to 12 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a distance ranging from about 7 to 12 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

In a preferred embodiment, the resilient couplings 512 further include one or more first bumpers 568 and one or more second bumpers 570 for slidingly supporting the sensor 504. In a preferred embodiment, the first bumpers 568 are located on one side of the bond pads 564 and the second bumpers 570 are located on another side of the bond pads 564. In a preferred embodiment, the first bumpers 568 and the second bumpers 570 are proximate to the bond pads

564. The width W_{568} of the first bumpers 568 may range, for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{568} of the first bumpers 568 range from about 3 to 5 mils in order to optimally minimize stresses. The width W_{570} of the second bumpers 570 may range, for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{570} of the second bumpers 570 range from about 3 to 5 mils in order to optimally minimize stresses. In a preferred embodiment, the resilient couplings 512 are coupled to the bond pads 564 using conventional solder equipment and processes. In a preferred embodiment, the resilient couplings 512 are coupled to the bottom surface 532 of the cavity 516 of the housing 502 using conventional solder equipment and processes.

The sliding supports 514 slidingly support the sensor 504. The sliding supports 514 are preferably coupled to the bottom surface 532 of the cavity 516 of the housing 502. The sliding supports 514 may, for example, be tungsten or ceramic. In a preferred embodiment, the sliding supports 514 are tungsten in order to optimally provide a standard packaging process. In a preferred embodiment, the sliding supports 514 have an approximately square cross sectional shape. The cross sectional area of the sliding supports 514 may range, for example, from about 400 to 1600 square mils, individually. In a preferred embodiment, the cross sectional area of the sliding supports 514 ranges from about 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{514} of the sliding supports 514 may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{514} of the sliding supports 514 ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses. The number of sliding supports 514 preferably depends on having sufficient sliding supports 514 to slidingly support the sensor 504.

In a preferred embodiment, there is a first sliding support 514a, a second sliding support 514b, a third sliding support 514c, and a fourth sliding support 514d. The first sliding support 514a is preferably located adjacent to one side of the resilient couplings 512. The second sliding support 514b is preferably located adjacent to the first sliding support 514a. The third sliding support 514c is

preferably located adjacent to one side of the resilient couplings 512 and approximately perpendicular to the first sliding support 514a. The fourth sliding support 514d is preferably located adjacent to the third sliding support 514c.

The first sliding support 514a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the first sliding support 514a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The second sliding support 514b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the second sliding support 514b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The third sliding support 514c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the third sliding support 514c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance

ranging from about 20 to 25 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The fourth sliding support 514d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the fourth sliding support 514d is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 514 are coupled to the bottom surface 532 of the cavity 516 of the housing 502 using conventional means of integrating the sliding supports 514 into the housing 502.

The electrical connections 510 preferably electrically couple the sensor 504 to the housing 502. In a preferred embodiment, the electrical connections 510 are wire bonds. The electrical connections 510 may, for example, be any number of conventional commercially available wire bonds of the type aluminum or gold. In a preferred embodiment, the electrical connections 510 are gold in order to optimally provide compatibility with the metal of the sensor 504. In a preferred embodiment, there is a first electrical connection 510a and a second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 518c of the housing 502 to the top parallel planar surface 550 of the sensor 504. The second electrical connection 510b preferably electrically couples the fourth planar surface 518d of the housing 502 to the middle parallel planar surface 552 of the sensor 504. In a preferred embodiment, the electrical connections 510 are coupled to the housing 502 using conventional wire bonding equipment and processes. In a preferred embodiment, the electrical connections 510 are coupled to the sensor 504 using conventional wire bonding equipment and processes.

The lid assembly 506 is preferably coupled to the housing 502. The lid assembly 506 preferably includes a lid 572 and a getter 574. The lid 572 may, for example, be Kovar™ or ceramic. In a preferred embodiment, the lid 572 is alloy 42 in order to optimally provide vacuum sealing. The lid 572 may, for example, be plated with an assortment of metals. In a preferred embodiment, the lid 572 is plated with an industry standard composite layer of gold/nickel/gold/nickel in order to provide good solderability. In a preferred embodiment, the length L_{572} of the lid 572 is at least 0.010 inches less than the length of the second planar surface 518b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{572} of the lid 572 is at least 0.010 inches less than the width of the second planar surface 518b in order to optimally provide good alignment tolerance. In a preferred embodiment, the height H_{572} of the lid 572 ranges from about 0.01 inches to 0.02 in order to optimally provide planarity with the housing 502.

The getter 574 may, for example, be any commercially available getter. In a preferred embodiment, the length L_{574} of the getter 574 is about 0.125 inches less than the length L_{572} of the lid 572 in order to optimally provide good vacuum ambient and alignment tolerance. In a preferred embodiment, the width W_{574} of the getter 574 is about 0.125 inches less than the width W_{572} of the lid 572 in order to optimally provide good vacuum ambient and alignment tolerance. The height H_{574} of the getter 574 may range, for example, from about 0.005 inches to 0.020 inches. In a preferred embodiment, the height H_{574} of the getter 574 ranges from about 0.005 inches to 0.015 inches in order to optimally provide good vacuum ambient.

The lid 572 preferably includes a bottom surface 576. The getter 574 is preferably coupled to the bottom surface 576 of the lid 572 using conventional welding equipment and processes. The bottom surface 576 of the lid 572 is preferably coupled to the housing 502 via a solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 518b of the housing 502 using conventional solder equipment and processes. The solder preform 578 may, for example, be eutectic or non-eutectic. In a preferred embodiment, the solder preform 578 is eutectic in order to optimally provide

good yield strength with a reasonable melt temperature. The solder preform 578 is preferably an approximately rectangular ring that conforms to the shape of the second planar surface 518b. In a preferred embodiment, the outer length L_{578} of the solder preform 578 is at least 0.010 inches less than the outer length of the second planar surface 518b in order to optimally provide good alignment tolerance. In a preferred embodiment, the exterior width W_{578} of the solder preform 578 is at least 0.010 inches less than the outer width of the second planar surface 518b in order to optimally provide good alignment tolerance. In a preferred embodiment, the height H_{578} of the solder preform 578 ranges from about 0.0025 inches to 0.0035 in order to optimally provide a good vacuum seal. In a preferred embodiment, the interior length L_{578a} of the solder preform 578 is at least as long as the interior length of the second planar surface 518b in order to optimally provide good alignment tolerance and a good solder seal. In a preferred embodiment, the interior width W_{578a} of the solder preform 578 is at least as wide as the interior width of the second planar surface 518b in order to optimally provide good alignment tolerance and a good solder seal. The lid 572 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 502, the sensor 504, and the lid 506 are preferably vacuum-sealed to remove excess gas from the cavity 516.

The controller assembly 508 preferably includes an adhesive 580, a controller 582, one or more wire bonds 584, and an encapsulant 586. The controller assembly 508 is preferably coupled to the bottom exterior surface 522 of the housing 502. The adhesive 580 is preferably coupled to the contact pad 538. The adhesive 580 may, for example, be solder, epoxies or silicone-based. In a preferred embodiment, the adhesive 580 is silicone-based in order to optimally provide stress relief.

The controller 582 is preferably coupled to the adhesive 580. The controller 582 may, for example, be an integrated circuit chip. In a preferred embodiment, the controller 582 is an application specific integrated chip in order to optimally provide close-loop control of the sensor 504. The adhesive 580 is preferably cured using conventional curing methods for the adhesive 580 used.

The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 540. The wire bonds 584 may, for example, be aluminum or gold. In a preferred embodiment, the wire bonds 584 are gold in order to optimally provide compatibility with the housing 502 metal. The wire bonds 584 preferably couple the bond pads 540 to the controller 582. The wire bonds 584 are preferably coupled to the bond pads 540 using conventional wire bonding equipment and processes. The wire bonds 584 are coupled to the controller 582 using conventional wire bonding equipment and processes.

The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586. In a preferred embodiment, the depth of the encapsulant ranges from about 0.05 inches to 0.06 inches in order to optimally provide a hermetic seal. The encapsulant 586 may, for example, be glob top polymer. In a preferred embodiment, the encapsulant 586 is glob top polymer in order to optimally provide a hermetic seal. The encapsulant 586 is preferably cured using conventional curing methods for the encapsulant 586 used.

In an alternate embodiment, the housing 502 further includes circuit components. The circuit components may be integrated into the housing 502, for example, on any of the planar surfaces 518, any of the first exterior surfaces 520a, the bottom exterior surface 522, or the bottom surface 532. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 522 in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally provide a reduced system 100 size.

In an alternate embodiment, the lid assembly 506 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 514 are optional.

In an alternate embodiment, the getter 574 is optional.

In an alternate embodiment, the exterior bond pads 536 are optional

Referring to Fig. 5M, in an alternate embodiment, there is a first bond pad 564b and a second bond pad 564c. The bond pads 564b and 564c may be substantially equal in size, horizontally proximate to each other, and have an

approximately rectangular cross-sectional shape. The bond pads 564b and 564c may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 564b and 564c have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pads 564b and 564c may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pads 564b and 564c range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5N, in an alternate embodiment, there is a bond pad 564d. The bond pad 564d may have an approximately oval cross-sectional shape. The bond pad 564d may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 564d has an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pad 564d may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pad 564d ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5O, in an alternate embodiment, there is a bond pad 564e and a bond pad 564f. The bond pads 564e and 564f may be substantially equal in size, vertically proximate to each other, and have an approximately oval cross-sectional shape. The bond pads 564e and 564f may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 564e and 564f have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pads 564e and 564f may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pads 564e and 564f range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5P, in an alternate embodiment, there is a bond pad 564g. The bond pad 564g may have an approximately tri-oval cross-sectional shape. The bond pad 564g may have an approximate cross-sectional area ranging

from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 564g has an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pad 564g may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pad 564g ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5Q, in an alternate embodiment, there is a single bond pad 564h. The bond pad 564h may have an approximately oct-oval cross-sectional shape. The bond pad 564h may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 564h has an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize stresses. The height H_{564} of the bond pad 564h may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pad 564h ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5R, in an alternate embodiment, there is bond pad 564i and a bond pad 564j. The bond pads 564i and 564j may be substantially equal in size, vertically proximate to each other, and have an approximately rectangular cross-sectional shape. The bond pads 564i and 564j may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 564i and 564j have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize stresses. The height H_{564} of the bond pads 564i and 564j may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pads 564i and 564j range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5S, in an alternate embodiment, there is a bond pad 564k, a bond pad 564l, and a bond pad 564m. The bond pads 564k, 564l, and 564m may be substantially equal in size, vertically proximate to each other, and have an approximately rectangular cross-sectional shape. The bond pads 564k, 564l, and 564m may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 564k,

564l, and 564m have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pads 564k, 564l, and 564m may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pads 564k, 564l, and 564m range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5T, in an alternate embodiment, there is a single bond pad 564n. The bond pad 564n may have an approximately wavy sided rectangular cross-sectional shape. The bond pad 564n may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 564n has an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pad 564n may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pad 564n ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5U, in an alternate embodiment, there is a bond pad 564o and a bond pad 564p. The bond pads 564o and 564p may be horizontally proximate to each other and have an approximately rectangular cross-sectional shape. The bond pad 564o is approximately smaller in size than the bond pad 564p. The bond pads 564o and 564p may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 564o and 564p have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{564} of the bond pads 564o and 564p may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{564} of the bond pads 564o and 564p ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 5V, in an alternate embodiment, there is a resilient coupling 512b and a resilient coupling 512c that may be substantially equal and are vertically proximate to each other. The resilient couplings 512b and 512c may have an approximate total cross-sectional area ranging from about 9025 to

13225 square mils. In a preferred embodiment, the resilient couplings 512b and 512c have an approximate total cross-sectional area ranging from about 10000 to 12100 square mils in order to optimally minimize thermal stresses. The height H_{512} of the resilient couplings 512b and 512c may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{512} of the resilient couplings 512b and 512c ranges from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

Referring to Figs. 5W through 5Y, in several alternate embodiments, the sliding supports 514 include one or more sliding supports 514e, 514f, or 514g. In an alternate embodiment, the sliding supports 514e may have an approximately rectangular cross-sectional shape. The sliding supports 514e may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 514e have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{514} of the sliding supports 514e may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{514} of the sliding supports 514e ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the sliding supports 514f may have an approximately triangular cross-sectional shape. The sliding supports 514f may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 514f have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{514} of the sliding supports 514f may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{514} of the sliding supports 514f ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the sliding supports 514g may have an approximately circular cross-sectional shape. The sliding supports 514g may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 514g have an approximate cross-sectional area ranging from 625 to 1225 square mils,

individually, in order to optimally minimize thermal stresses. The height H_{514} of the sliding supports 514g may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{514} of the sliding supports 514g ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

Referring to Figs. 6A through 6L, an alternate embodiment of the sensor package 405 preferably includes a housing 602, the sensor 504, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 602. The controller assembly 508 is preferably coupled to the top of the housing 602. The sensor 504 is preferably coupled within the housing 602.

The housing 602 is preferably coupled to the sensor 504, the lid assembly 506, the controller assembly 508, the electrical connections 510, the resilient couplings 512, and the sliding supports 514. The housing 602 preferably includes a cavity 604, one or more planar surfaces 606, one or more exterior surfaces 608, and a bottom exterior surface 610. The cavity 604 preferably includes a first wall 612, a second wall 614, a third wall 616, and a fourth wall 618. The first wall 612 and the third wall 616 are preferably approximately parallel to each other and the second wall 614 and the fourth wall 618 are preferably approximately parallel to each other. The second wall 614 and the fourth wall 618 are also preferably perpendicular to the first wall 612 and the third wall 616. The cavity 604 preferably includes a bottom surface 620. The bottom surface 620 may, for example, be ceramic. In a preferred embodiment, the bottom surface 620 is gold plated in order to optimally provide solderability. The housing 602 may, for example, be any number of conventional commercially available housings of the type ceramic, plastic or metal. In a preferred embodiment, the housing 602 is ceramic in order to optimally provide vacuum sealing capability.

The housing 602 preferably includes a first planar surface 606a, a second planar surface 606b, a third planar surface 606c, and a fourth planar surface 606d. The first planar surface 606a preferably includes one or more planar bond pads 622. The planar bond pads 622 are preferably approximately rectangularly shaped. The planar bond pads 622 are preferably used to wire bond the controller 508 to the housing 602. The second planar surface 606b may, for

example, be plated with a metal. In a preferred embodiment, the second planar surface 606b is plated with gold in order to optimally provide solderability. The third planar surface 606c may, for example, be plated with a metal. In a preferred embodiment, the third planar surface 606c is plated with gold in order to optimally provide wire bonding. The fourth planar surface 606d may, for example, be plated with a metal. In a preferred embodiment, the fourth planar surface 606d is plated with gold in order to optimally provide wire bonding. The resilient couplings 512, the third planar surface 606c and the fourth planar surface 606d are preferably coupled to the one of the planar bond pads 622 on the first planar surface 606a by electrical paths molded into the housing 602.

The housing 602 preferably includes a plurality of first exterior surfaces 608a and a plurality of second exterior surfaces 608b. In a preferred embodiment, there are four first exterior surfaces 608a and four second exterior surfaces 608b forming an approximate octagon. The second exterior surfaces 608b preferably couple the first exterior surfaces 608a to each other. The first exterior surfaces 608a preferably include one or more exterior bond pads 624. The exterior bond pads 624 are preferably approximately rectangularly shaped. The exterior bond pads 624 are preferably electrically coupled to the planar bond pads 622 by electrical paths molded into the housing 602. The exterior bond pads 624 may, for example, be used for solder paste, solder ball or leads attachment. In a preferred embodiment, the exterior bond pads 624 are used to solder the sensor package 405 to the substrate 410. In an alternate embodiment, the exterior bond pads 624 are on a single first exterior surface 608a.

The bottom exterior surface 610 of the housing 602 preferably includes one or more bond pads 626. The bond pads 626 are preferably approximately circular in shape. The bond pads 626 may, for example, used for solder paste, solder balls or leads attachments. In a preferred embodiment, the bond pads 626 are gold plated in order to optimally provide solderability. The number of bond pads 626 preferably depend on having sufficient bond pads 626 to connect the sensor module 405 to the substrate 410. The planar bond pads 622 are preferably electrically coupled to the bond pads 626 by electrical paths molded into the housing 602.

The sensor 504 is preferably resiliently attached to the housing 602 by the resilient couplings 512, slidingly supported by the sliding supports 514, and electrically coupled to the housing 602 by the electrical connections 510. The bond pads 564 are preferably located in the passive region 566 of the sensor 502. In a preferred embodiment, there is a single approximately rectangular bond pad 564a in the passive region 566.

The resilient couplings 512 preferably resiliently attach the bond pads 564 to the housing 602. The resilient couplings 512 may electrically couple the sensor 504 to the housing 602. The resilient couplings 512 are preferably coupled to the bottom surface 620 of the cavity 604 of the housing 602. The resilient couplings 512 may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the resilient couplings 512 are located a perpendicular distance ranging from about 7 to 12 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a distance ranging from about 7 to 12 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses. In a preferred embodiment, the resilient couplings 512 are coupled to the bond pads 564 using conventional solder equipment and processes. In a preferred embodiment, the resilient couplings 512 are coupled to the bottom surface 620 of the cavity 604 of the housing 602 using conventional solder equipment and processes. In a preferred embodiment, there is a single approximately rectangular resilient coupling 512a.

The sliding supports 514 preferably slidingly support the sensor 502. The sliding supports 514 are preferably coupled to the bottom surface 620 of the cavity 604 of the housing. In a preferred embodiment, the sliding supports 514 have an approximately square cross-sectional shape. The number of sliding supports 514 preferably depends on having sufficient sliding supports 514 to slidingly support the sensor 504. In a preferred embodiment, there is the first sliding support 514a, the second sliding support 514b, the third sliding support

514c, and the fourth sliding support 514d. The first sliding support 514a is preferably located adjacent to one side of the resilient couplings 512. The second sliding support 514b is preferably located adjacent to the first sliding support 514a. The third sliding support 514c is preferably located adjacent to one side of the resilient couplings 512 and approximately perpendicular to the first sliding support 514a. The fourth sliding support 514d is preferably located adjacent to the third sliding support 514c.

The first sliding support 514a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the first sliding support 514a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses.

The second sliding support 514b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the second sliding support 514b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses.

The third sliding support 514c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the third sliding

support 514c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses.

The fourth sliding support 514d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the fourth sliding support 514d is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 514 are coupled to the bottom surface 620 of the cavity 604 of the housing 602 using conventional means of integrating the sliding supports 614 into the housing 602.

The electrical connections 510 preferably electrically couple the sensor 504 to the housing 602. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 606c of the housing 602 to the top parallel planar surface 550 of the sensor 504. The second electrical connection 510b preferably electrically couples the fourth planar surface 606d of the housing 602 to the middle parallel planar surface 552 of the sensor 504. In a preferred embodiment, the electrical connections 510 are coupled to the housing 602 using conventional wire bonding equipment and processes. In a preferred embodiment, the electrical connections 510 are coupled to the sensor 504 using conventional wire bonding equipment and processes.

The lid assembly 506 is preferably coupled to the housing 602. The bottom surface 576 of the lid 572 is preferably coupled to the housing 602 via the solder preform 578. In a preferred embodiment, the length L_{572} of the lid 572 is

at least 0.010 inches less than the length of the second planar surface 606b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{572} of the lid 572 is at least 0.010 inches less than the width of the second planar surface 606b in order to optimally provide good alignment tolerance.

The solder preform 578 is coupled to the second planar surface 606b of the housing 602 using conventional solder equipment and processes. The solder preform 578 is preferably a rectangular ring that conforms to the shape of the second planar surface 606b. In a preferred embodiment, the outer length L_{578} of the solder preform 578 is at least 0.010 inches less than the outer length of the second planar surface 606b in order to optimally provide good alignment tolerance. In a preferred embodiment, the exterior width W_{578} of the solder preform 578 is at least 0.010 inches less than the outer width of the second planar surface 606b in order to optimally provide good alignment tolerance. In a preferred embodiment, the interior length L_{578a} of the solder preform 578 is at least as long as the interior length of the second planar surface 606b in order to optimally provide good alignment tolerance and a good solder seal. In a preferred embodiment, the interior width W_{578a} of the solder preform 578 is at least as wide as the interior width of the second planar surface 606b in order to optimally provide good alignment tolerance and a good solder seal. The lid 572 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 602, the sensor 504, and the lid assembly 506 are preferably vacuum-sealed to remove excess gas from the cavity 604.

The lid 572 further includes a top surface 628. The controller assembly 508 is preferably coupled to the top surface 628 of the lid 572. The adhesive 580 is preferably coupled to the top surface 628 of the lid 572. The controller 582 is preferably coupled to the adhesive 580. The adhesive 580 is preferably cured using conventional curing methods for the adhesive 580 used. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 622. The wire bonds 584 are coupled to the planar bond pads 622 using conventional wire bonding equipment and processes.

In an alternate embodiment, the housing 602 further includes circuit components. The circuit components may be integrated into the housing 602, for example, on any of the planar surfaces 606 or any of the first exterior surfaces 608a. In a preferred embodiment, the circuit components are integrated into the first planar surface 606a in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally provide a reduced system 100 size.

In an alternate embodiment, the lid assembly 506 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 514 are optional.

In an alternate embodiment, the getter 574 is optional.

In an alternate embodiment, the exterior bond pads 624 are optional.

In several alternate embodiments, the bond pads 564 may be one of the following: the bond pads 564b and 564c, the bond pad 564d, the bond pads 564e and 564f, the bond pad 564g, the bond pad 564h, the bond pads 564i and 564j, the bond pads 564k, 564l and 564m, the bond pad 564n or the bond pads 564o and 564p as referenced to in Figs. 5M through 5U.

In an alternate embodiment, the resilient couplings 512 may be the resilient couplings 512b and 512c as referenced to in Fig. 5V.

In an alternate embodiment, the sliding supports 514 may be the sliding supports 514b, 514c or 514d as referenced to in Figs. 5W through 5Y.

Referring to Figs. 7A through 7L, an alternate embodiment of the sensor package 405 preferably includes the housing 502, the sensor 504, a lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 502. The controller assembly 508 is preferably coupled to the bottom of the housing 502. The sensor 504 is preferably coupled within the housing 502.

The housing 502 is preferably coupled to the sensor 504, the lid assembly 702, the controller assembly 508, the electrical connections 510, the resilient couplings 512, and the sliding supports 514.

The sensor 504 is preferably resiliently attached to the housing 502 by the resilient couplings 512, slidingly supported by the sliding supports 514, and electrically coupled to the housing 502 by the electrical connections 510. In a preferred embodiment, there is a single approximately rectangular bond pad 564 located in the passive region 566.

The resilient couplings 512 preferably resiliently attach the bond pads 564 to the housing 502. The resilient couplings 512 may electrically couple the sensor 504 to the housing 502. The resilient couplings 512 are preferably coupled to the bottom surface 532 of the cavity 516 of the housing 502. In a preferred embodiment, there is a single approximately rectangular resilient coupling 512a.

The sliding supports 514 preferably slidingly support the sensor 504. The sliding supports 514 are preferably coupled to the bottom surface 532 of the cavity 516 of the housing 502. In a preferred embodiment, the sliding supports 514 have an approximately square cross- sectional shape. The number of sliding supports 514 preferably depends on having sufficient sliding supports 514 to slidingly support the sensor 504. In a preferred embodiment, there is the first sliding support 514a, the second sliding support 514b, the third sliding support 514c, and the fourth sliding support 514d. The first sliding support 514a is preferably located adjacent to one side of the resilient couplings 512. The second sliding support 514b is preferably located adjacent to the first sliding support 514a. The third sliding support 514c is preferably located adjacent to one side of the resilient couplings 512 and approximately perpendicular to the first sliding support 514a. The fourth sliding support 514d is preferably located adjacent to the third sliding support 514c.

The electrical connections 510 preferably electrically couple the sensor 504 to the housing 502. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 518c of the housing 502 to the top parallel planar surface 550 of the sensor 504. The second electrical connection 510b preferably electrically couples the fourth

planar surface 518d of the housing 502 to the middle parallel planar surface 552 of the sensor 504.

The lid assembly 702 is preferably coupled to the housing 502. The lid assembly 702 preferably includes a lid 704, a getter 706 and a spring 708. The lid 704 further preferably includes a bottom surface 710 and a top surface 712. The lid 704 may, for example, be Kovar™ or ceramic. In a preferred embodiment, the lid 704 is alloy 42 in order to optimally provide vacuum sealing. In a preferred embodiment, the lid 704 is plated with an industry standard composite layer of gold/nickel/gold/nickel in order to provide good solderability. In a preferred embodiment, the length L_{704} of the lid 704 is at least 0.010 inches less than the length of the second planar surface 518b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{704} of the lid 704 is at least 0.010 inches less than the width of the second planar surface 518b in order to optimally provide good alignment tolerance. In a preferred embodiment, the height H_{704} of the lid 704 ranges from about 0.01 inches to 0.02 in order to optimally provide planarity with the housing 502.

The getter 706 may, for example, be any commercially available getter. In a preferred embodiment, the length L_{706} of the getter 706 is 0.125 inches less than the length L_{704} of the lid 704 in order to optimally provide good vacuum ambient and alignment tolerance. In a preferred embodiment, the width W_{706} of the getter 706 is 0.125 inches less than the width W_{704} of the lid 704 in order to optimally provide good vacuum ambient and alignment tolerance. The height H_{706} of the getter 706 may range, for example, from about 0.005 inches to 0.020 inches. In a preferred embodiment, the height H_{706} of the getter 706 ranges from about 0.005 inches to 0.015 inches in order to optimally provide good vacuum ambient.

The spring 708 may, for example, be fabricated from 0.003" stainless steel or beryllium copper strips. In a preferred embodiment the spring 708 is stainless steel in order to optimally provide good mechanical strength and stable properties. The spring 708 is preferably H-shaped. The spring preferably includes a center bar 714 and four arms 716. The spring 708 is preferably welded to the bottom surface 710 of the lid 704. The four arms 716 preferably curl

downwardly away from the bottom surface 710 of the lid 704. The four arms 716 preferably couple the bottom surface 710 of the lid 704 to the top parallel planar surface 550 of the sensor 504. The spring 708 preferably secures the sensor 504 to the resilient couplings 512. The getter 706 is preferably coupled to the bottom surface 710 of the lid 704 using conventional welding equipment and processes. The spring 708 preferably electrically couples the sensor 504 to the housing 502.

The bottom surface 710 of the lid 704 is preferably coupled to the housing 502 via the solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 518b of the housing 502 using conventional solder equipment and processes. The lid 704 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 502, the sensor 504, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 516.

The controller assembly 508 is preferably coupled to the bottom exterior surface 522 of the housing 502. The adhesive 580 is preferably coupled to the contact pad 538. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 540. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the housing 502 further includes circuit components. The circuit components may be integrated into the housing 502, for example, on any of the planar surfaces 518 or any of the first exterior surfaces 520a. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 522 in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally provide a reduced system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 514 are optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the exterior bond pads 536 are optional.

In several alternate embodiments, the bond pads 564 may be one of the following: the bond pads 564b and 564c, the bond pad 564d, the bond pads 564e and 564f, the bond pad 564g, the bond pad 564h, the bond pads 564i and 564j, the bond pads 564k, 564l and 564m, the bond pad 564n or the bond pads 564o and 564p as referenced to in Figs. 5M through 5U.

In an alternate embodiment, the resilient couplings 512 may be the resilient couplings 512b and 512c as referenced to in Fig. 5V.

In an alternate embodiment, the sliding supports 514 may be the sliding supports 514b, 514c or 514d as referenced to in Figs. 5W through 5Y.

Referring to Figs. 8A through 8L, an alternate embodiment of the sensor package 405 preferably includes the housing 602, the sensor 504, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 602. The controller assembly 508 is preferably coupled to the top of the housing 602. The sensor 504 is preferably coupled within the housing 602.

The housing 602 is preferably coupled to the sensor 504, the lid assembly 702, the controller assembly 508, the electrical connections 510, the resilient couplings 512, and the sliding supports 514.

The sensor 504 is preferably resiliently attached to the housing 602 by the resilient couplings 512, slidingly supported by the sliding supports 514, and electrically coupled to the housing 602 by the electrical connections 510. In a preferred embodiment, there is a single approximately rectangular bond pad 564 located in the passive region 566.

The resilient couplings 512 preferably resiliently attach the bond pads 564 to the housing 602. The resilient couplings 512 may electrically couple the sensor 504 to the housing 602. The resilient couplings 512 are preferably coupled to the bottom surface 620 of the cavity 604 of the housing 602. In a preferred embodiment, there is a single approximately rectangular resilient coupling 512.

The sliding supports 514 slidingly support the sensor 504. The sliding supports 514 are preferably coupled to the bottom surface 620 of the cavity 604

of the housing 602. In a preferred embodiment, the sliding supports 514 have an approximately square cross- sectional shape. The number of sliding supports 514 preferably depends on having sufficient sliding supports 514 to slidingly support the sensor 504. In a preferred embodiment, there is the first sliding support 514a, the second sliding support 514b, the fourth sliding support 514c, and the fourth sliding support 514d. The first sliding support 514a is preferably located adjacent to one side of the resilient couplings 512. The second sliding support 514b is preferably located adjacent to the first sliding support 514a. The third sliding support 514c is preferably located adjacent to one side of the resilient couplings 512 and approximately perpendicular to the first sliding support 514a. The fourth sliding support 514d is preferably located adjacent to the third sliding support 514c.

The electrical connections 510 preferably electrically couple the sensor 504 to the housing 602. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 606c of the housing 602 to the top parallel planar surface 550 of the sensor 504. The second electrical connection 510b preferably electrically couples the fourth planar surface 606d of the housing 602 to the middle parallel planar surface 552 of the sensor 504.

The lid assembly 702 is preferably coupled to the housing 602. The four arms 716 preferably couple the bottom surface of the lid 710 to the top parallel planar surface 550 of the sensor 504. The spring 708 preferably secures the sensor 504 to the resilient couplings 512. The bottom surface 710 of the lid 704 is preferably coupled to the housing 602 via the solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 606b of the housing 602 using conventional solder equipment and processes. The lid 704 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 602, the sensor 504, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 604.

The controller assembly 508 is preferably coupled to the top surface 712 of the lid 704. The adhesive 580 is preferably coupled to the top surface 712 of

the lid 704. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 622. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the housing 602 further includes circuit components. The circuit components may be integrated into the housing 602, for example, on any of the planar surfaces 606 or any of the first exterior surfaces 608a. In a preferred embodiment, the circuit components are integrated into the first planar surface 606a in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally provide a reduced system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 514 are optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the exterior bond pads 624 are optional.

In several alternate embodiments, the bond pads 564 may be one of the following: the bond pads 564b and 564c, the bond pad 564d, the bond pads 564e and 564f, the bond pad 564g, the bond pad 564h, the bond pads 564i and 564j, the bond pads 564k, 564l and 564m, the bond pad 564n or the bond pads 564o and 564p as referenced to in Figs. 5M through 5U.

In an alternate embodiment, the resilient couplings 512 may be the resilient couplings 512b and 512c as referenced to in Fig. 5V.

In an alternate embodiment, the sliding supports 514 may be the sliding supports 514b, 514c or 514d as referenced to in Figs. 5W through 5Y.

Referring to Figs. 9A through 9N, an alternate embodiment of the sensor package 405 preferably includes the housing 502, a sensor 902, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 502. The controller assembly 508 is preferably coupled

to the bottom of the housing 502. The sensor 902 is preferably coupled within the housing 502.

The housing 502 is preferably coupled to the sensor 902, the lid assembly 506, the controller assembly 508, the electrical connections 510, one or more resilient couplings 904, and one or more sliding supports 940.

The sensor 902 is preferably resiliently attached to the housing 502 by the resilient couplings 904, electrically coupled to the housing by the electrical connections 510, and slidingly supported by the sliding supports 940. The sensor 902 preferably has an approximately rectangular cross-sectional shape. The sensor 902 preferably includes a first passive region 928 on one end and a second passive region 930 on the opposite end. The sensor 902 preferably further includes an active region 942 located between the first passive region 928 and the second passive region 930. In a preferred embodiment, the sensor 902 includes a first member 906, a second member 908, and a third member 910. The first member 906 is preferably on top of the second member 908 and the second member 908 is preferably on top of the third member 910. In a preferred embodiment, the first member 906, the second member 908, and the third member 910 are a micro machined sensor substantially as disclosed in copending U. S. Patent Application Serial No. _________, Attorney Docket No. 14737.737, filed on ____________, the contents of which are incorporated herein by reference.

The first member 906 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the first member 906 includes a top parallel planar surface 912. The second member 908 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the second member 908 includes a middle parallel planar surface 914. The third member 910 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the third member 910 includes a bottom parallel planar surface 916.

The bottom parallel planar surface 916 of the sensor 902 preferably includes a first side 918, a second side 920, a third side 922, and a fourth side 924. The first side 918 and the third side 922 are preferably approximately

parallel to each other and the second side 920 and the fourth side 924 are preferably approximately parallel to each other and preferably approximately perpendicular to the first side 918 and the third side 922.

In a preferred embodiment, the bottom parallel planar surface 916 of the sensor 902 includes one or more bond pads 926. In a preferred embodiment, there is one or more first bond pads 926a and one or more second bond pads 926b. In a preferred embodiment, the first bond pads 926a are located in the first passive region 928 of the bottom parallel planar surface 916 of the sensor 902. The first bond pads 926a may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the first side 918 of the bottom parallel planar surface 916 of the sensor 902 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second side 920 of the bottom parallel planar surface 916 of the sensor 902. In a preferred embodiment, the first bond pads 926a are located a perpendicular distance ranging from about 7 to 12 mils from the first side 918 of the bottom parallel planar surface 916 of the sensor 902 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 7 to 12 mils from the second side 920 of the bottom parallel planar surface 916 of the sensor 902 in order to optimally minimize thermal stresses.

In a preferred embodiment, the second bond pads 926b are located in the second passive region 930 of the bottom parallel planar surface 916 of the sensor 902. The second bond pads 926b may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the third side 922 of the bottom parallel planar surface 916 of the sensor 902 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second side 920 of the bottom parallel planar surface 916 of the sensor 902. In a preferred embodiment, the second bond pads 926b are located a perpendicular distance ranging from about 7 to 12 mils from the third side 922 of the bottom parallel planar surface 916 of the sensor 902 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 7 to 12 mils from the second side 920 of the bottom parallel planar surface 916 of the sensor 902 in order to optimally minimize thermal stresses.

The first bond pads 926a may, for example, be used for solder, conductive epoxy, non-conductive epoxy, or glass frit bonding. In a preferred embodiment, the first bond pads 926a are used for solder bonding in order to optimally provide good manufacturability. The second bond pads 926b may, for example, be used for solder, conductive epoxy, non-conductive epoxy, or glass frit bonding. In a preferred embodiment, the second bond pads 926b are used for solder bonding in order to optimally provide good manufacturability.

In a preferred embodiment, the bond pads 926 contact area is maximized in order to optimize the shock tolerance of the sensor 902. In a preferred embodiment, the bond pads 926 have minimal discontinuities in order to optimize the distribution of thermal stresses in the sensor 902. In several alternate embodiments, there is a plurality of bond pads 926 in order to optimize the relief of thermal stresses in the sensor 902.

The length L_{926a} of the first bond pads 926a may range, for example, from about 180 to 240 mils. In a preferred embodiment, the length L_{926a} of the first bond pads 926a range from about 200 to 220 mils in order to optimally minimize thermal stresses. The width W_{926a} of the first bond pads 926a may range, for example, from about 15 to 25 mils. In a preferred embodiment, the width W_{926a} of the first bond pads 926a range from about 18 to 22 mils in order to optimally minimize thermal stresses. The height H_{926a} of the first bond pads 926a may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926a} of the first bond pads 926a range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses. In a preferred embodiment, there is a single approximately rectangular bond pad 926a.

The length L_{926b} of the second bond pads 926b may range, for example, from about 180 to 240 mils. In a preferred embodiment, the length L_{926b} of the second bond pads 926b range from about 200 to 240 mils in order to optimally minimize thermal stresses. The width W_{926b} of the second bond pads 926b may range, for example, from about 15 to 25 mils. In a preferred embodiment, the width W_{926b} of the second bond pads 926b range from about18 to 22 mils in order to optimally minimize thermal stresses. The height H_{926b} of the second bond pads 926b may range, for example, from about 0.1 to 1 micron. In a preferred

embodiment, the height H_{926b} of the second bond pads 926b range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses. In a preferred embodiment, there is a single approximately rectangular second bond pad 926b.

The resilient couplings 904 preferably resiliently attach the bond pads 926 to the housing 502. The resilient couplings 904 may electrically couple the sensor 902 to the housing 502. In a preferred embodiment, the resilient couplings 904 are solder preforms. In a preferred embodiment, the resilient couplings 904 have minimal discontinuities in order to optimize the distribution of thermal stresses in the sensor 902. In several alternate embodiments, there is a plurality of resilient couplings 904 in order to optimize the relief of thermal stresses in the sensor 902. In a more preferred embodiment, the resilient couplings 904 preferably have an approximately rectangular cross-sectional shape. The resilient couplings 904 may, for example, be any number of conventional commercially available solder preforms of the type eutectic or non-eutectic. In a preferred embodiment, the resilient couplings 904 are eutectic in order to optimally provide good yield strength with a reasonable melt temperature. In a preferred embodiment, there is one or more first resilient couplings 904a and one or more second resilient couplings 904b.

The length L_{904a} of the first resilient couplings 904a may range, for example, from about 200 to 250 mils. In a preferred embodiment, the length L_{904a} of the first resilient couplings 904a range from about 225 to 235 mils in order to optimally minimize thermal stresses. The width W_{904a} of the first resilient couplings 904a may range, for example, from about 20 to 35 mils. In a preferred embodiment, the width W_{904a} of the first resilient couplings 904a range from about 25 to 30 mils in order to optimally minimize thermal stresses. The height H_{904a} of the first resilient couplings 904a may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{904a} of the first resilient couplings 904a range from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

The length L_{904b} of the second resilient couplings 904b may range, for example, from about 200 to 250 mils. In a preferred embodiment, the length

L_{904b} of the second resilient couplings 904b range from about 225 to 235 mils in order to optimally minimize thermal stresses. The width W_{904b} of the second resilient couplings 904b may range, for example, from about 20 to 35 mils. In a preferred embodiment, the width W_{904b} of the second resilient couplings 904b range from about 25 to 30 mils in order to optimally minimize thermal stresses. The height H_{904b} of the second resilient couplings 904b may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{904b} of the second resilient couplings 904b range from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

The first resilient couplings 904a may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the first resilient couplings 904a are located a perpendicular distance ranging from about 7 to 12 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a distance ranging from about 7 to 12 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The second resilient couplings 904b may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the third wall 528 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the second resilient couplings 904b are located a perpendicular distance ranging from about 7 to 12 mils from the third wall 528 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a distance ranging from about 7 to 12 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

In a preferred embodiment, the first resilient couplings 904a further include one or more first bumpers 932 and one or more second bumpers 934 for slidingly supporting the sensor 902.

In a preferred embodiment, the first bumpers 932 of the first resilient couplings 904a are located on one side of the first bond pads 926a and the second bumpers 934 of the first resilient couplings 904a are located on another side of the first bond pads 926a. In a preferred embodiment, the first bumpers 932 of the first resilient couplings 904a and the second bumpers 934 of the first resilient couplings 904a are proximate to the first bond pads 926a. The width W_{932} of the first bumpers 932 of the first resilient couplings 904a may range, for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{932} of the first bumpers 932 of the first resilient couplings 904a range from about 3 to 5 mils in order to optimally minimize thermal stresses. The width W_{934} of the second bumpers 934 of the first resilient couplings 904a may range, for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{934} of the second bumpers 934 of the first resilient couplings 904a range from about 3 to 5 mils in order to optimally minimize thermal stresses.

In a preferred embodiment, the second resilient couplings 904b further include one or more first bumpers 936 and one or more second bumpers 938 for slidingly supporting the sensor 902. In a preferred embodiment, the first bumpers 936 of the second resilient couplings 904b are located on one side of the second bond pads 926b and the second bumpers 938 of the second resilient couplings 904b are located on another side of the second bond pads 926b. In a preferred embodiment, the first bumpers 936 of the second resilient couplings 904b and the second bumpers 938 of the second resilient couplings 904b are proximate to the second bond pads 926b. The width W_{936} of the first bumpers 936 of the second resilient couplings 904b may range, for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{936} of the first bumpers 936 of the second resilient couplings 904b range from about 3 to 5 mils in order to optimally minimize thermal stresses. The width W_{938} of the second bumpers 938 of the second resilient couplings 904b may range for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{938} of the second bumpers 938 of the second resilient couplings 904b range from about 3 to 5 mils in order to optimally minimize thermal stresses. In a preferred embodiment, the resilient couplings 904 are coupled to the bond pads 926 using conventional solder

equipment and processes. In a preferred embodiment, the resilient couplings 904 are coupled to the bottom surface 532 of the cavity 516 of the housing 502 using conventional solder equipment and processes. In a preferred embodiment, there is a single approximately rectangular first resilient coupling 904a. In a preferred embodiment, there is a single approximately rectangular second resilient coupling 904b.

The sliding supports 940 preferably slidingly support the sensor 902. The sliding supports 940 are preferably coupled to the bottom surface 536 of the cavity 516 of the housing 502. In a preferred embodiment, the sliding supports 940 preferably have an approximately square cross sectional shape. The number of sliding supports 940 preferably depends on having sufficient sliding supports 940 to slidingly support the sensor 902. The sliding supports 940 may, for example, be tungsten or ceramic. In a preferred embodiment, the sliding supports 940 are tungsten in order to optimally provide a standard packaging process. The cross-sectional area of the sliding supports 940 may range, for example, from about 400 to 1600 square mils, individually. In a preferred embodiment, the cross sectional area of the sliding supports 940 ranges from about 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{940} of the sliding supports 940 may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{940} of the sliding supports 940 ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In a preferred embodiment, there is a first sliding support 940a, a second sliding support 940b, a third sliding support 940c, and a fourth sliding support 940d. The first sliding support 940a is preferably located adjacent to one side of the first resilient couplings 926a. The second sliding support 940b is preferably located adjacent to the first sliding support 940a. The third sliding support 940c is preferably located adjacent to one side of the resilient couplings 926a and approximately perpendicular to the first sliding support 940a. The fourth sliding support 940d is preferably located adjacent to the third sliding support 940c.

The first sliding support 940a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 524 of the

cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the first sliding support 940a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The second sliding support 940b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the second sliding support 940b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The third sliding support 940c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 526 of the cavity 516 of the housing 502. In a preferred embodiment, the third sliding support 940c is located a perpendicular distance ranging from about90 to 105 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance from about 20 to 25 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses.

The fourth sliding support 940d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 524 of the cavity 516 of the housing 502 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 526 of the

cavity 516 of the housing 502. In a preferred embodiment, the fourth sliding support 940d is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 524 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 526 of the cavity 516 of the housing 502 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 940 are coupled to the bottom surface 532 of the cavity 516 of the housing 502 using conventional means of integrating the sliding supports 940 into the housing 502.

The electrical connections 510 preferably electrically couple the sensor 902 to the housing 502. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 518c of the housing to the top parallel planar surface 912 of the sensor 902. The second electrical connection 510b preferably electrically couples the fourth planar surface 518d of the housing 502 to the middle parallel planar surface 914 of the sensor 902. In a preferred embodiment, the electrical connections 510 are coupled to the housing 502 using conventional wire bonding equipment and processes. In a preferred embodiment, the electrical connections 510 are coupled to the sensor 902 using conventional wire bonding equipment and processes.

The lid assembly 506 is preferably coupled to the housing 502. The bottom surface 576 of the lid 572 is preferably coupled to the housing 502 via the solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 518b of the housing 502 using conventional solder equipment and processes. The solder preform 578 is preferably a rectangular ring that conforms to the shape of the second planar surface 518b. The lid 572 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 502, the sensor 902, and the lid 506 are preferably vacuum-sealed to remove excess gas from the cavity 516.

The controller assembly 508 is preferably coupled to the bottom exterior surface 522 of the housing 502. The adhesive 580 is preferably coupled to the contact pad 538. The controller 582 is preferably coupled to the adhesive 580.

The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 540. The wire bonds 584 are coupled to the bond pads 540 using conventional wire bonding equipment and processes. The wire bonds 584 are coupled to the controller 582 using conventional wire bonding equipment and processes. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the second passive region 930 is optional. The second bond pads 926b are located in the active region 942.

In an alternate embodiment, the housing 502 further includes circuit components. The circuit components may be integrated into the housing 502, for example, on any of the planar surfaces 518 or any of the first exterior surfaces 520a. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 522 in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally provide reduced system 100 size.

In an alternate embodiment, the lid assembly 506 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 940 are optional.

In an alternate embodiment, the getter 574 is optional.

In an alternate embodiment, the bond pads 926 are not the same shape.

In an alternate embodiment, the exterior bond pads 536 are optional.

Referring to Fig. 9O, in an alternate embodiment, the bond pads 926 include a bond pad 926c and a bond pad 926d. The bond pads 926c and 926d may be substantially equal in size, horizontally proximate to each other, and have an approximately rectangular cross-sectional shape. The bond pads 926c and 926d may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 926c and 926d have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pads 926c and 926d may range, for example, from about 0.1 to 1

micron. In a preferred embodiment, the height H_{926} of the bond pads 926c and 926d range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9P, in an alternate embodiment, the bond pads 926 include a bond pad 926e. The bond pad 926e may have an approximately oval cross-sectional shape. The bond pad 926e may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 12 has an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pad 926e may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pad 926e ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9Q, in an alternate embodiment, the bond pads 926 include a bond pad 926f and a bond pad 926g. The bond pads 926f and 926g may be substantially equal in size, vertically proximate to each other, and have an approximately oval cross-sectional shape. The bond pads 926f and 926g may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 926f and 926g have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pads 926f and 926g may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pads 926f and 926g range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9R, in an alternate embodiment, the bond pads 926 include a bond pad 926h. The bond pad 926h may have an approximately tri-oval cross-sectional shape. The bond pad 926h may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 926h have an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pad 926h may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the

bond pad 926h ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9S, in an alternate embodiment, the bond pads 926 include a bond pad 926i. The bond pad 926i may have an approximately oct-oval cross-sectional shape. The bond pad 926i may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 926i have an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pad 926i may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pad 926i ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9T, in an alternate embodiment, the bond pads 926 include a bond pad 926j and a bond pad 926k. The bond pads 926 j and 926k may be substantially equal in size, vertically proximate to each other, and have an approximately rectangular cross-sectional shape. The bond pads 926j and 926k may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 926j and 926k have an approximate total cross-sectional area ranging from 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pads 926j and 926k may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pads 926j and 926k range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9U, in an alternate embodiment, the bond pads 926 include a bond pad 926l, a bond pad 926m, and a bond pad 926n. The bond pads 926l, 926m, and 926n may be substantially equal in size, vertically proximate to each other, and have an approximately rectangular cross-sectional shape. The bond pads 926l, 926m, and 926n may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 926l, 926m, and 926n have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pads 926l, 926m and

926n may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pads 926l, 926m and 926n ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9V in an alternate embodiment, the bond pads 926 include a bond pad 926o. The bond pad 926o may have an approximately wavy sided rectangular cross-sectional shape. The bond pad 926o may have an approximate cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pad 926o have an approximate cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally provide minimize thermal stresses. The height H_{926} of the bond pad 926o may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pad 926o ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9W, in an alternate embodiment, the bond pads 926 include a bond pad 926p and a bond pad 926q. The bond pads 926p and 926q may be horizontally proximate to each other and have an approximately rectangular cross-sectional shape. The bond pad 926p is approximately smaller in size than the second bond pad 926q. The bond pads 926p and 926q may have an approximate total cross-sectional area ranging from about 4000 to 8750 square mils. In a preferred embodiment, the bond pads 926p and 926q have an approximate total cross-sectional area ranging from about 5625 to 7050 square mils in order to optimally minimize thermal stresses. The height H_{926} of the bond pads 926p and 926q may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{926} of the bond pads 926p and 926q range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 9X, in an alternate embodiment, the resilient couplings 904 include a resilient coupling 904c and a resilient coupling 904d that are substantially equal and are vertically proximate to each other. The resilient couplings 904c and 904d may have an approximate total cross-sectional area ranging from about 9025 to 13225 square mils. In a preferred embodiment, the resilient couplings 904c and 904d have an approximate total cross-sectional area ranging from about 10000 to 12100 in order to optimally minimize thermal

stresses. The height H_{904} of the resilient couplings 904c and 904d may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{904} of the resilient couplings 904c and 904d range from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

Referring to Fig. 9Y through 9AA, in several alternate embodiments, the sliding supports 940 include one or more sliding supports 940e, 940f, or 940g. In an alternate embodiment, the sliding support 940e may have an approximately rectangular cross-sectional shape. The sliding supports 940e may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 940e have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{940} of the sliding supports 940e may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{940} of the sliding supports 940e ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the sliding supports 940f may have an approximately triangular cross-sectional shape. The sliding supports 940f may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 940f have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{940} of the sliding supports 940f may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{940} of the sliding supports 940f ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the sliding supports 940g may have an approximately circular cross-sectional shape. The sliding supports 940g may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 940g have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{940} of the sliding supports 940g may range, for example, from about 0.5 to 3 mils. In a

preferred embodiment, the height H_{940} of the sliding supports 940g ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

Referring to Figs. 10A through 10N, an alternate embodiment of the sensor package 405 preferably includes the housing 602, the sensor 902, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 602. The controller assembly 508 is preferably coupled to the top of the housing 602. The sensor 902 is preferably coupled within the housing 602.

The housing 602 is preferably coupled to the sensor 904, the lid assembly 506, the controller assembly 508, the electrical connections 510, the resilient couplings 904, and the sliding supports 940.

The sensor 902 is preferably resiliently attached to the housing 602 by the resilient couplings 904, electrically coupled to the housing 602 by the electrical connections 510, and slidingly supported by the sliding supports 940. In a preferred embodiment, there is the single approximately rectangular first bond pad 926a located in the first passive region 928 of the sensor 902 and the single approximately rectangular second bond pad 926b located in the second passive region 930 of the sensor 902.

The resilient couplings 904 preferably resiliently attach the bond pads 926 to the housing 602. The resilient couplings 904 may electrically couple the sensor 902 to the housing 602. The first resilient couplings 904a may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the first resilient couplings 904a are located a perpendicular distance ranging from about 7 to 12 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a distance ranging from about 7 to 12 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses. The second resilient couplings 904b may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the third wall 616 of the cavity 604 of

the housing 602 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the second resilient couplings 904b are located a perpendicular distance ranging from about 7 to 12 mils from the third wall 616 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a distance ranging from about 7 to 12 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses. In a preferred embodiment, the resilient couplings 904 are coupled to the bond pads 926 using conventional solder equipment and processes. In a preferred embodiment, the resilient couplings 904 are coupled to the bottom surface 620 of the cavity 604 of the housing 602 using conventional solder equipment and processes. In a preferred embodiment, there is the single approximately rectangular first resilient coupling 904a and the single approximately rectangular second resilient coupling 904b.

The sliding supports 940 are preferably coupled to the bottom surface 620 of the cavity 604 of the housing. In a preferred embodiment, the sliding supports 940 have an approximately square cross sectional shape. The number of sliding supports 940 preferably depends on having sufficient sliding supports 940 to slidingly support the sensor 902. In a preferred embodiment, there is the first sliding support 940a, the second sliding support 940b, the third sliding support 940c, and the fourth sliding support 940d. The first sliding support 940a is preferably located adjacent to one side of the first resilient couplings 904a. The second sliding support 940b is preferably located adjacent to the first sliding support 940a. The third sliding support 940c is preferably located adjacent to one side of the first resilient couplings 904a and approximately perpendicular to the first sliding support 940a. The fourth sliding support 940d is preferably located adjacent to the third sliding support 940c.

The first sliding support 940a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the first sliding

support 940a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses.

The second sliding support 940b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the second sliding support 940b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses.

The third sliding support 940c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the third sliding support 940c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 612 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses.

The fourth sliding support 940d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 612 of the cavity 604 of the housing 602 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 614 of the cavity 604 of the housing 602. In a preferred embodiment, the fourth sliding support 940d is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 612 of the cavity 604 of the housing 602 in order to

optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 614 of the cavity 604 of the housing 602 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 940 are coupled to the bottom surface 620 of the cavity 604 of the housing 602 using conventional means of integrating the sliding supports 940 into the housing 602.

The electrical connections 510 preferably electrically couple the sensor 902 to the housing 602. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 606c of the housing to the top parallel planar surface 912 of the sensor 902. The second electrical connection 510b preferably electrically couples the fourth planar surface 606d of the housing 602 to the middle parallel planar surface 914 of the sensor 902. In a preferred embodiment, the electrical connections 510 are coupled to the housing 602 using conventional wire bonding equipment and processes. In a preferred embodiment, the electrical connections 510 are coupled to the sensor 902 using conventional wire bonding equipment and processes.

The lid assembly 506 is preferably coupled to the housing 602. The bottom surface 576 of the lid 572 is preferably coupled to the housing 602 via the solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 606b of the housing 602 using conventional solder equipment and processes. The solder preform 578 is preferably a rectangular ring that conforms to the shape of the second planar surface 606b. The lid 572 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 602, the sensor 902, and the lid 506 are preferably vacuum-sealed to remove excess gas from the cavity 604.

The lid 572 further includes the top surface 628. The controller assembly 508 is preferably coupled to the top surface 628 of the lid 572. The adhesive 580 is preferably coupled to the top surface 628 of the lid 572. The controller 582 is preferably coupled to the adhesive 580. The adhesive 580 is preferably cured using conventional curing methods for the adhesive 580 used. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 622.

The wire bonds 584 are coupled to the planar bond pads 622 using conventional wire bonding equipment and processes.

In an alternate embodiment, the second passive region 930 is optional. The second bond pads 926b are preferably located in the active region 942.

In an alternate embodiment, the housing 602 further includes circuit components. The circuit components may be integrated into the housing 602, for example, on any of the planar surfaces 606 or any of the first exterior surfaces 608a. In a preferred embodiment, the circuit components are integrated into the first planar surface 606a in order to optimally reduce the size of the sensor module. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 506 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 940 are optional.

In an alternate embodiment, the getter 574 is optional.

In an alternate embodiment, the bond pads 926 are not the same shape.

In an alternate embodiment, the exterior bond pads 624 are optional.

In several alternate embodiments, the bond pads 926 may be one of the following: the bond pads 926c and 926d, the bond pad 926e, the bond pads 926f and 926g, the bond pad 926h, the bond pad 926i, the bond pads 926j and 926k, the bond pads 926l, 926m and 926n, the bond pad 926o or the bond pads 926p and 926q as referenced to in Figs. 9O through 9W.

In an alternate embodiment, the resilient couplings 904 may be the resilient couplings 904c and 904d as referenced to in Fig. 9X.

In several alternate embodiments, the sliding supports 940 may be the sliding supports 940e, 940f, or 940g as referenced to in Figs. 9Y through 9AA.

Referring to Figs. 11A through 11N, an alternate embodiment of the sensor package 405 preferably includes the housing 502, the sensor 902, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 502. The controller assembly 508 is

preferably coupled to the bottom of the housing 502. The sensor 902 is preferably coupled within the housing 502.

The housing 502 is preferably coupled to the sensor 902, the lid assembly 702, the controller assembly 508, the electrical connections 510, the resilient couplings 904, and the sliding supports 940.

The sensor 902 is preferably resiliently attached to the housing 502 by the resilient couplings 904, electrically coupled to the housing 502 by the electrical connections 510, and slidingly supported by the sliding supports 940. In a preferred embodiment, there is the single approximately rectangular first bond pad 926a located in the first passive region 928 of the sensor 902 and the single approximately rectangular second bond pad 926b located in the second passive region 930 of the sensor 902.

The resilient couplings 904 preferably resiliently attach the bond pads 926 to the housing 502. The resilient couplings 904 may electrically couple the sensor 902 to the housing 502. The resilient couplings 904 are preferably coupled to the bottom surface 532 of the cavity 516 of the housing 502. In a preferred embodiment, there is the single approximately rectangular first resilient coupling 904a and the single approximately rectangular second resilient coupling 904b.

The sliding supports 940 are preferably coupled to the bottom surface 532 of the cavity 516 of the housing 502. In a preferred embodiment, the sliding supports 940 preferably have an approximately square cross sectional shape. The number of sliding supports 940 preferably depends on having sufficient sliding supports 940 to slidingly support the sensor 902. In a preferred embodiment, there is the first sliding support 940a, the second sliding support 940b, the third sliding support 940c, and the fourth sliding support 940d. The first sliding support 940a is preferably located adjacent to one side of the first resilient couplings 904a. The second sliding support 940b is preferably located adjacent to the first sliding support 940a. The third sliding support 940c is preferably located adjacent to one side of the first resilient couplings 904a and approximately perpendicular to the first sliding support 940a. The fourth sliding support 940d is preferably located adjacent to the third sliding support 940c.

The electrical connections 510 preferably electrically couple the sensor 902 to the housing 502. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 518c of the housing 502 to the top parallel planar surface 912 of the sensor 902. The second electrical connection 510b preferably electrically couples the fourth planar surface 518d of the housing 502 to the middle parallel planar surface 914 of the sensor 902.

The lid assembly 702 is preferably coupled to the housing 502. The four arms 716 preferably couple the bottom surface of the lid 710 to the top parallel planar surface 912 of the sensor 902. The spring 708 preferably secures the sensor 902 to the resilient couplings 904. The bottom surface 710 of the lid 704 is preferably coupled to the housing 502 via the solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 518b of the housing 502 using conventional soldering equipment and processes. The lid 704 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 502, the sensor 902, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 516.

The controller assembly 508 is preferably coupled to the bottom exterior surface 522 of the housing 502. The adhesive 580 is preferably coupled to the contact pad 538. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 540. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the second passive region 930 is optional. The second bond pads 926b are preferably located in the active region 942.

In an alternate embodiment, the housing 502 further includes circuit components. The circuit components may be integrated into the housing 502, for example, on any of the planar surfaces 518 or any of the first exterior surfaces 520a. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 522 in order to optimally reduce the size of the sensor

module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 940 are optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the bond pads 926 are not the same shape.

In an alternate embodiment, the exterior bond pads 536 are optional.

In several alternate embodiments, the bond pads 926 may be one of the following: the bond pads 926c and 926d, the bond pad 926e, the bond pads 926f and 926g, the bond pad 926h, the bond pad 926i, the bond pads 926j and 926k, the bond pads 926l, 926m and 926n, the bond pad 926o or the bond pads 926p and 926q as referenced to in Figs. 9O through 9W.

In an alternate embodiment, the resilient couplings 904 may be the resilient couplings 904c and 904d as referenced to in Fig. 9X.

In several alternate embodiments, the sliding supports 940 may be the sliding supports 940e, 940f, or 940g as referenced to in Figs. 9Y through 9AA.

Referring to Figs. 12A through 12N, an alternate embodiment of the sensor package 405 preferably includes the housing 602, the sensor 902, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 602. The controller assembly 508 is preferably coupled to the top of the housing 602. The sensor 902 is preferably coupled within the housing 602.

The housing 602 is preferably coupled to the sensor 902, the lid assembly 702, the controller assembly 508, the electrical connections 510, the sliding supports 940 and the resilient couplings 904.

The sensor 902 is preferably resiliently attached to the housing 602 by the resilient couplings 904, slidingly supported by the sliding supports 940 and electrically coupled to the housing 602 by the electrical connections 510. In a preferred embodiment, there is the single approximately rectangular first bond pad 926a located in the first passive region 928 of the sensor 902 and the single

approximately rectangular second bond pad 926b located in the second passive region 930 of the sensor 902.

The resilient couplings 904 preferably resiliently attaches the bond pads 926 to the housing 602. The resilient couplings 904 may electrically couple the sensor 902 to the housing 602. The resilient couplings 904 are preferably coupled to the bottom surface 620 of the cavity 604 of the housing 602. In a preferred embodiment, there is the single approximately rectangular first resilient coupling 904a and the single approximately rectangular second resilient coupling 904b.

The sliding supports 940 are preferably coupled to the bottom surface 620 of the cavity 604 of the housing. In a preferred embodiment, the sliding supports 940 preferably have an approximately square cross sectional shape. The number of sliding supports 940 preferably depends on having sufficient sliding supports 940 to slidingly support the sensor 902. In a preferred embodiment, there is the first sliding support 940a, the second sliding support 940b, the third sliding support 940c, and the fourth sliding support 940d. The first sliding support 940a is preferably located adjacent to one side of the first resilient couplings 904a. The second sliding support 940b is preferably located adjacent to the first sliding support 940a. The third sliding support 940c is preferably located adjacent to one side of the first resilient couplings 904a and approximately perpendicular to the first sliding support 940a. The fourth sliding support 940d is preferably located adjacent to the third sliding support 940c.

The electrical connections 510 preferably electrically couple the sensor 902 to the housing 602. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 606c of the housing 602 to the top parallel planar surface 912 of the sensor 902. The second electrical connection 510b preferably electrically couples the fourth planar surface 606d of the housing 602 to the middle parallel planar surface 914 of the sensor 504.

The lid assembly 702 is preferably coupled to the housing 602. The four arms 716 preferably couple the bottom surface of the lid 710 to the top parallel

planar surface 912 of the sensor 902. The spring 708 preferably secures the sensor 902 to the resilient couplings 904. The bottom surface 710 of the lid 704 is preferably coupled to the housing 602 via the solder preform 578. The solder preform 578 is preferably coupled to the second planar surface 606b of the housing 602 using conventional soldering equipment and processes. The lid 704 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 602, the sensor 902, and the lid assembly 702 are vacuum-sealed to remove excess gas from the cavity 604.

The controller assembly 508 is preferably coupled to the top surface 712 of the lid 704. The adhesive 580 is preferably coupled to the top surface 712 of the lid 704. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 622. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the second passive region 930 is optional. The second bond pads 926b are preferably located in the active region 942.

In an alternate embodiment, the housing 602 further includes circuit components. The circuit components may be integrated into the housing 602, for example, on any of the planar surfaces 606 or any of the first exterior surfaces 608a. In a preferred embodiment, the circuit components are integrated into the first planar surface 606a in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 940 are optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the bond pads 926 are not the same shape.

In an alternate embodiment, the exterior bond pads 624 are optional.

In several alternate embodiments, the bond pads 926 may be one of the following: the bond pads 926c and 926d, the bond pad 926e, the bond pads 926f

and 926g, the bond pad 926h, the bond pad 926i, the bond pads 926j and 926k, the bond pads 926l, 926m and 926n, the bond pad 926o or the bond pads 926p and 926q as referenced to in Figs. 9O through 9W.

In an alternate embodiment, the resilient couplings 904 may be the resilient couplings 904c and 904d as referenced to in Fig. 9X.

In several alternate embodiments, the sliding supports 940 may be the sliding supports 940e, 940f, or 940g as referenced to in Figs. 9Y through 9AA.

Referring to Figs. 13A through 13L, an alternate embodiment of the sensor package 405 preferably includes a housing 1302, a sensor 1304, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 1302. The controller assembly 508 is preferably coupled to the bottom of the housing 1302. The sensor 1304 is preferably coupled within the housing 1302.

The housing 1302 is preferably coupled to the sensor 1304, the lid assembly 506, the controller assembly 508, the electrical connections 510, one or more sliding supports 1372, and one or more resilient couplings 1306. The housing preferably includes a cavity 1308, one or more planar surfaces 1310, one or more exterior surfaces 1312, and a bottom exterior surface 1314. The cavity 1308 preferably includes a first wall 1316, a second wall 1318, a third wall 1320 and a fourth wall 1322. The first wall 1316 and the third wall 1320 are preferably approximately parallel to each other and the second wall 1318 and the fourth wall 1322 are preferably approximately parallel to each other. The second wall 1318 and the fourth 1322 wall are also preferably perpendicular to the first wall 1316 and the third wall 1320. The cavity 1308 preferably includes a bottom surface 1324. The bottom surface 1324 may be, for example, ceramic. In a preferred embodiment, the bottom surface 1324 is gold plated in order to optimally provide solderability.

In a preferred embodiment, the bottom surface 1324 further includes a recess 1326. The recess 1326 preferably includes a first wall 1328, a second wall 1330, a third wall 1332 and a fourth wall 1334. The first wall 1328 and the third wall 1332 are preferably approximately parallel to each other and the second wall 1330 and the fourth wall 1334 are preferably approximately parallel to each

other. The second wall 1330 and the fourth wall 1334 are also preferably perpendicular to the first wall 1328 and the third wall 1332. The recess 1326 preferably includes a bottom surface 1336.

The length L_{1326} of the recess 1326 may range, for example, from about 110 to 130 mils. In a preferred embodiment, the length L_{1326} of the recess 1326 ranges from about 115 to 125 mils in order to optimally minimize thermal stresses. The width W_{1326} of the recess 1326 may range, for example, from about 110 to 130 mils. In a preferred embodiment, the width W_{1326} of the recess 1326 ranges from about 115 to 125 mils in order to minimize thermal stresses. The height H_{1326} of the recess 1326 may range, for example, from about 1 to 2 mils. In a preferred embodiment, the height H_{1326} of the recess 1326 ranges from about 1.25 to 1.75 mils in order to optimally minimize thermal stresses.

In a preferred embodiment, the recess 1326 is located approximately in the center of the bottom surface 1326 of the cavity 1308 of the housing 1302. The first wall 1328 of the recess 1326 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1316 of the cavity 1308. In a preferred embodiment, the first wall 1328 of the recess 1326 is located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1316 of the cavity 1308 in order to optimally minimize thermal stresses. The second wall 1330 of the recess 1326 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1318 of the cavity 1308. In a preferred embodiment, the second wall 1330 of the recess 1326 is located a perpendicular distance ranging from about 85 to 95 mils from the second wall 1318 of the cavity 1308 in order to optimally minimize thermal stresses. The housing 1302 may, for example, be any number of conventional commercially available housings of the type ceramic, plastic or metal. In a preferred embodiment, the housing 1302 is ceramic in order to optimally provide vacuum sealing capability.

The bottom surface 1336 of the recess 1326 may, for example, be plated with a metal. In a preferred embodiment, the bottom surface 1336 of the recess 1326 is gold plated in order to optimally provide solderability.

The housing 1302 preferably includes a first planar surface 1310a, a second planar surface 1310b, a third planar surface 1310c, and a fourth planar surface 1310d. The first planar surface 1310a preferably includes one or more planar bond pads 1338. The planar bond pads 1338 are preferably approximately rectangularly shaped. The planar bond pads 1338 may, for example, be used for solder paste, solder balls or leads attachment. In a preferred embodiment, the planar bond pads 1338 are used to solder the sensor packages 405 to the substrate 410. The number of planar bond pads 1338 preferably depend on having sufficient planar bond pads 1338 to connect the controller assembly 508 to the housing 1302. The second planar surface 1310b may, for example, be plated with a metal. In a preferred embodiment, the second planar surface 1310b is plated with gold in order to optimally provide solderability. The third planar surface 1310c may, for example, be plated with a metal. In a preferred embodiment, the third planar surface 1310c is plated with gold in order to optimally provide wire bonding. The fourth planar surface 1310d may, for example, be plated with a metal. In a preferred embodiment, the fourth planar surface 1310d is plated with gold in order to optimally provide wire bonding.

The housing 1302 preferably includes a plurality of first exterior surfaces 1312a and a plurality of second exterior surfaces 1312b. In a preferred embodiment, there are four first exterior surfaces 1312a and four second exterior surfaces 1312b forming an approximate octagon. The second exterior surfaces 1312b preferably couple the first exterior surfaces 1312a to each other. The first exterior surfaces 1312a preferably include one or more exterior bond pads 1340. The exterior bond pads 1340 are preferably approximately rectangularly shaped. The exterior bond pads 1340 may, for example, be used for solder paste, solder balls or leads attachment. In a preferred embodiment, the exterior bond pads 1340 are used to solder the sensor packages 405 to the substrate 410. The number of exterior bond pads 1340 preferably depend on having sufficient exterior bond pads 1340 to connect the controller assembly 508 to the housing 1302. In an alternate embodiment, the exterior bond pads 1340 are on a single first exterior surface 1312a.

The bottom exterior surface 1314 of the housing 1302 preferably includes a contact pad 1342, one or more bond pads 1344, and one or more connecting pads 1346. The contact pad 1342 may, for example, be plated with a metal. In a preferred embodiment, the contact pad 1342 is gold-plated in order to optimally provide a reliable electrical contact. The planar bond pads 1338 on the first planar surface 1310a are preferably electrically coupled to the bond pads 1344 on the bottom exterior surface 1314 by electrical paths molded into the housing 1302. The resilient couplings 1306, the third planar surface 1310c and the fourth planar surface 1310d are preferably coupled to the bond pads 1344 on the bottom exterior surface 1314 by electrical paths molded into the housing 1302. The bond pads 1344 may, for example, be plated with metal. In a preferred embodiment, the bond pads 1344 are gold plated in order to optimally provide wire bonding. The number of bond pads 1344 preferably depend on having sufficient bond pads 1344 to connect the controller assembly 508 to the housing 1302. The connecting pads 1346 preferably connect the contact pad 1342 to the bond pads 1344. The connecting pads 1346 may, for example, metal plated. In a preferred embodiment, the connecting pads 1346 are gold-plated in order to optimally provide a conductive pathway between the contact pad 1342 and the bond pads 1344. The exterior bond pads 1340 are preferably electrically coupled to the bond pads 1344 by electrical paths molded into the housing 1302. In a preferred embodiment, there is a first connecting pad 1346a and a second connecting pad 1346b.

The sensor 1304 is preferably resiliently attached to the housing 1302 by the resilient couplings 1306, slidingly supported by the sliding supports 1372 and electrically coupled to the housing 1302 by the electrical connections 510. The sensor 1304 is an entirely active region. The sensor 1304 preferably has an approximately rectangular cross-sectional shape. In a preferred embodiment, the sensor 1304 includes a first member 1348, a second member 1350, and a third member 1352. The first member 1348 is preferably on top of the second member 1350 and the second member 1350 is preferably on top of the third member 1352. In a preferred embodiment, the first member 1348, the second member 1350, and the third member 1352 are a micro machined sensor substantially as disclosed in

copending U. S. Patent Application Serial No. ________, Attorney Docket No. 14737.737, filed on ___________, the contents of which are incorporated herein by reference.

The first member 1348 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the first member 1348 includes a top parallel planar surface 1354. The second member 1350 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the second member 1350 includes a middle parallel planar surface 1356. The third member 1352 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the third member 1352 includes a bottom parallel planar surface 1358.

The bottom parallel planar surface 1358 of the sensor 1304 preferably includes a first side 1360, a second side 1362, a third side 1364, and a fourth side 1366. The first side 1360 and the third side 1364 are preferably approximately parallel to each other and the second side 1362 and the fourth side 1366 are preferably approximately parallel to each other and preferably approximately perpendicular to the first side 1360 and the third side 1364.

In a preferred embodiment, the bottom parallel planar surface 1358 of the sensor 1304 includes one or more bond pads 1368. In a preferred embodiment, the bond pads 1368 are located at the approximate center of the bottom parallel planar surface 1358 of the sensor 1304. The bond pads 1368 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first side 1360 of the bottom parallel planar surface 1358 of the sensor 1304 and may, for example, be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second side 1362 of the bottom parallel planar surface 1358 of the sensor 1304. In a preferred embodiment, the bond pads 1368 are located a perpendicular distance ranging from about 85 to 95 mils from the first side 1360 of the bottom parallel planar surface 1358 of the sensor 1304 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 85 to 95 mils from the second side 1362 of the bottom parallel planar surface 1358 of the sensor 1304 in order to optimally minimize thermal stresses.

The bond pads 1368 may, for example, be used for solder, conductive epoxy, non-conductive epoxy, or glass frit bonding. In a preferred embodiment, the bond pads 1368 are used for solder bonding in order to optimally provide good manufacturability. In a preferred embodiment, the bond pads 1368 contact area is maximized in order to optimize the shock tolerance of the sensor 1304. In a preferred embodiment, the bond pads 1368 have minimal discontinuities in order to optimize the distribution of thermal stresses in the sensor 1304. In several alternate embodiments, there are a plurality of bond pads 1368 in order to optimize the relief of thermal stresses in the sensor 1304. The bond pads 1368 preferably have an approximately circular cross-sectional shape. The total diameter D_{1368} of the bond pads 1368 may range, for example, from about 50 to 100 mils. In a preferred embodiment, the total diameter D_{1368} of the bond pads 1368 range from about 70 to 80 mils in order to optimally minimize thermal stresses. The height H_{1368} of the bond pads 1368 may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{1368} of the bond pads 1368 range from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses. In a preferred embodiment, there is a single approximately circular bond pad 1368a.

The resilient couplings 1306 preferably resiliently attach the bond pads 1368 to the housing 1302. The resilient couplings 1306 may electrically couple the sensor 1304 to the housing 1302. The resilient couplings 1306 are preferably coupled to the bottom surface 1336 of the recess 1326 of the cavity 1308 of the housing 1302. In a preferred embodiment, the resilient couplings 1306 are solder preforms. In a preferred embodiment, the resilient couplings 1306 have minimal discontinuities in order to optimize the distribution of thermal stresses in the sensor 1304. In a preferred embodiment, there is a plurality of resilient couplings 1306 in order to optimize the relief of thermal stresses in the sensor 1304. In a more preferred embodiment, the resilient couplings 1306 have an approximate cross-sectional circular shape. The resilient couplings 1306 may, for example, be any number of conventional commercially available solder preforms of the type eutectic or non-eutectic. In a preferred embodiment, the resilient

coupling 1306 is eutectic in order to optimally provide good yield strength with a reasonable melt temperature.

The cross-sectional area A_{1306} of the resilient couplings 1306 may range, for example, from about 9025 to 13225 square mils. In a preferred embodiment, the cross-sectional area A_{1306} of the resilient couplings 1306 ranges from about 10000 to 12100 square mils in order to optimally minimize thermal stresses. The height H_{1306} of the resilient couplings 1306 may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{1306} of the resilient couplings 1306 range from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 2 to 7 mils from the first wall 1328 of the recess 1326 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 2 to 7 mils from the second wall 1330 of the recess 1326 of the cavity 1308 of the housing 1302. In a preferred embodiment, the resilient couplings 1306 are located a perpendicular distance ranging from about 3 to 5 mils from the first wall 1328 of the recess 1326 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a distance ranging from about 3 to 5 mils from the second wall 1330 of the recess 1326 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

In a preferred embodiment, the resilient couplings 1306 further include one or more bumpers 1370 for slidingly supporting the sensor 1304. In a preferred embodiment, the bumpers 1370 have an approximately annular cross-sectional shape. In a preferred embodiment, the bumpers 1370 surround the bond pads 1368. In a preferred embodiment, the bumpers 1370 are proximate to the bond pad 1368. The width W_{1370} of the bumpers 1370 may range, for example, from about 2 to 6 mils. In a preferred embodiment, the width W_{1370} of the bumpers 1370 range from about 3 to 5 mils in order to optimally minimize thermal stresses. In a preferred embodiment, the resilient couplings 1306 are coupled to the bond pads 1368 using conventional solder equipment and processes. In a preferred embodiment, the resilient couplings 1306 are coupled

to the bottom surface 1336 of the recess 1326 of the cavity 1308 of the housing 1302 using conventional solder equipment and processes. In a more preferred embodiment, there is a single approximately circular resilient coupling 1306a.

The sliding supports 1372 preferably slidingly support the sensor 1304. The sliding supports 1372 are preferably coupled to the bottom surface 1324 of the cavity 1308 of the housing 1302. The sliding supports 1372 may, for example, be tungsten or ceramic. In a preferred embodiment, the sliding supports 1372 are tungsten in order to optimally provide a standard packaging process. The cross sectional area A_{1372} of the sliding supports 1372 may range, for example, from about 400 to 1600 square mils, individually. In a preferred embodiment, the cross sectional area A_{1372} of the sliding supports 1372 ranges from about 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{1372} of the sliding supports 1372 may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{1372} of the sliding supports 1372 ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

The number of sliding supports 1372 preferably depends on having sufficient sliding supports 1372 to slidingly support the sensor 1302. In a preferred embodiment, the sliding supports 1372 preferably have an approximately square cross sectional shape. In a preferred embodiment, there is a first sliding support 1372a, a second sliding support 1372b, a third sliding support 1372c, and a fourth sliding support 1372d. The first sliding support 1372a is preferably located adjacent to one side of the resilient couplings 1306. The second sliding support 1372b is preferably located adjacent to the first sliding support 1372a. The third sliding support 1372c is preferably located adjacent to another side of the resilient couplings 1306. The fourth sliding support 1372d is preferably located adjacent to the third sliding support 1372c.

The first sliding support 1372a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the first sliding

support 1372a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

The second sliding support 1372b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the second sliding support 1372b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

The third sliding support 1372c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the third sliding support 1372c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

The fourth sliding support 1372d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the fourth sliding support 1372b is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to

optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 1372 are coupled to the bottom surface 1324 of the cavity 1308 of the housing 1302 using conventional means of integrating the sliding supports 1372 into the housing 1302.

The electrical connections 510 preferably electrically couple the sensor 1304 to the housing 1302. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 1310c of the housing 1302 to the top parallel planar surface 1354 of the sensor 1304. The second electrical connection 510b preferably electrically couples the fourth planar surface 1310d of the housing 1302 to the middle parallel planar surface 1356 of the sensor 1304. In a preferred embodiment, the electrical connections 510 are coupled to the housing 1302 using conventional solder equipment and processes. In a preferred embodiment, the electrical connections 510 are coupled to the sensor 1304 using conventional solder equipment and processes.

The lid assembly 506 is preferably coupled to the housing 1302. In a preferred embodiment, the length L_{572} of the lid 572 is at least 0.010 inches less than the length of the second planar surface 1310b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{572} of the lid 572 is at least 0.010 inches less than the width of the second planar surface 1310b in order to optimally provide good alignment tolerance. The bottom surface 576 of the lid 572 is preferably coupled to the housing 1302 via the solder preform 578. In a preferred embodiment, the outer length L_{578} of the solder preform 578 is at least 0.010 inches less than the outer length of the second planar surface 1310b in order to optimally provide good alignment tolerance. In a preferred embodiment, the exterior width W_{578} of the solder preform 578 is at least 0.010 inches less than the outer width of the second planar surface 1310b in order to optimally provide good alignment tolerance. The solder preform 578 is preferably coupled to the second planar surface 1310b of the housing 1302 using conventional solder equipment and processes. The lid 572 is preferably coupled

to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 1302, the sensor 1304, and the lid 506 are preferably vacuum-sealed to remove excess gas from the cavity 1308.

The controller assembly 508 is preferably coupled to the bottom exterior surface 1314 of the housing 1302. The adhesive 580 is preferably coupled to the contact pad 1342. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 1344. The wire bonds 584 are preferably coupled to the bond pads 1344 using conventional wire bonding equipment and processes. The wire bonds 584 are preferably coupled to the controller 582 using conventional wire bonding equipment and processes. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the recess 1326 is optional. The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the resilient couplings 1306 are located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a distance ranging from about 85 to 95 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

In an alternate embodiment, the housing 1302 further includes circuit components. The circuit components may be integrated into the housing 1302, for example, on any of the planar surfaces 1310 or any of the first exterior surfaces 1312a. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 1314 in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 506 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 1372 are optional.

In an alternate embodiment, the getter 574 is optional.

In an alternate embodiment, the exterior bond pads 1340 are optional.

Referring to Fig. 13M, in an alternate embodiment, there is a bond pad 1368b. The bond pad 1368b may have an approximately oct-pie-wedge cross-sectional shape. The overall diameter D_{1368b} of the bond pad 1368b may range, for example, from about 50 to 100 mils. In a preferred embodiment, the overall diameter D_{1368b} of the bond pad 1368b ranges from about 70 to 80 mils in order to optimally minimize thermal stresses. The height H_{1368} of the bond pad 1368b may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{1368} of the bond pad 1368b ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 13N, in an alternate embodiment, there is bond pad 1368c. The bond pad 1368c may have an approximately hollow oct-pie-wedge cross-sectional shape. The overall diameter D_{1368c} of the bond pad 1368c may range, for example, from about 50 to 100 mils. In a preferred embodiment, the overall diameter D_{1368c} of the bond pad 1368c ranges from about 70 to 80 mils in order to optimally minimize thermal stresses. The height H_{1368} of the bond pad 1368c may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{1368} of the bond pad 1368c ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 13O, in an alternate embodiment, there is a bond pad 1368d. The bond pad 1368d has an approximately nine-circular cross-sectional shape. The overall diameter D_{1368d} of the bond pad 1368d may range, for example, from about 50 to 100 mils. In a preferred embodiment, the overall diameter D_{1368d} of the bond pad 1368d ranges from about 70 to 80 mils in order to optimally minimize thermal stresses. The height H_{1368} of the bond pad 1368d may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{1368} of the bond pad 1368d ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 13P, in an alternate embodiment, there is a bond pad 1368e. The bond pad 1368e has an approximately starburst cross-sectional shape. The overall diameter D_{1368e} of the bond pad 1368e may range, for example, from about 50 to 100 mils. In a preferred embodiment, the overall diameter D_{1368e} of the bond pad 1368e ranges from about 70 to 80 mils in order to optimally minimize thermal stresses. The height H_{1368} of the bond pad 1368e may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{1368} of the bond pad 1368e ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 13Q, in an alternate embodiment, there is a bond pad 1368f. The bond pad 1368f has an approximately sunburst cross-sectional shape. The overall diameter D_{1368f} of the bond pad 1368f may range, for example, from about 50 to 100 mils. In a preferred embodiment, the overall diameter D_{1368f} of the bond pad 1368f ranges from about 70 to 80 mils in order to optimally minimize thermal stresses. The height H_{1368} of the bond pad 1368f may range, for example, from about 0.1 to 1 micron. In a preferred embodiment, the height H_{1368} of the bond pad 1368f ranges from about 0.24 to 0.72 microns in order to optimally minimize thermal stresses.

Referring to Fig. 13V, in an alternate embodiment, there is a resilient coupling 1306b and a resilient coupling 1306c that are substantially equal and are vertically proximate to each other. The total cross-sectional area A_{1306} of the resilient couplings 1306b and 1306c may range, for example, from about 9025 to 13225 square mils. In a preferred embodiment, the total cross-sectional area A_{1306} of the resilient couplings 1306b and 1306c ranges from about 10000 to 12100 square mils in order to optimally minimize thermal stresses. The height H_{1306} of the resilient couplings 1306b and 1306c may range, for example, from about 2 to 4 mils. In a preferred embodiment, the height H_{1306} of the resilient couplings 1306b and 1306c ranges from about 2.5 to 3 mils in order to optimally minimize thermal stresses.

Referring to Figs. 13W through 13Y, in several alternate embodiments, the sliding supports 1372 include one or more sliding supports 1372e, 1372f, or 1372g. In an alternate embodiment, the sliding supports 1372e may have an

approximately rectangular cross-sectional shape. The sliding supports 1372e may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 1372e have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{1372} of the sliding supports 1372e may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{1372} of the sliding supports 1372e ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the sliding supports 1372f may have an approximately triangular cross-sectional shape. The sliding supports 1372f may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 1372f have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{1372} of the sliding supports 1372f may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{1372} of the sliding supports 1372f ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the sliding supports 1372g may have an approximately circular cross-sectional shape. The sliding supports 1372g may have an approximate cross-sectional area ranging from 400 to 1600 square mils, individually. In a preferred embodiment, the sliding supports 1372g have an approximate cross-sectional area ranging from 625 to 1225 square mils, individually, in order to optimally minimize thermal stresses. The height H_{1372} of the sliding supports 1372g may range, for example, from about 0.5 to 3 mils. In a preferred embodiment, the height H_{1372} of the sliding supports 1372g ranges from about 1 to 1.5 mils in order to optimally minimize thermal stresses.

In an alternate embodiment, the recess 1328 is optional. The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the resilient couplings 1306 are

located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a distance ranging from about 85 to 95 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

Referring to Figs. 14A through 14L, an alternate embodiment of the sensor package 405 preferably includes a housing 1402, the sensor 1304, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 1402. The controller assembly 508 is preferably coupled to the bottom of the housing 1402. The sensor 1304 is preferably coupled within the housing 1402.

The housing 1402 is preferably coupled to the sensor 1304, the lid assembly 506, the controller assembly 508, the electrical connections 510, the sliding supports 1372, and the resilient couplings 1306. The housing 1302 preferably includes a cavity 1404, one or more planar surfaces 1406, one or more exterior surfaces 1408, and a bottom exterior surface 1410. The cavity 1404 preferably includes a first wall 1412, a second wall 1414, a third wall 1416 and a fourth wall 1418. The first wall 1412 and the third wall 1416 are preferably approximately parallel to each other and the second wall 1414 and the fourth wall 1418 are preferably approximately parallel to each other. The second wall 1414 and the fourth 1418 wall are also preferably perpendicular to the first wall 1412 and the third wall 1416. The cavity 1404 preferably includes a bottom surface 1420. The bottom surface 1420 of the cavity 1404 may, for example, be metal plated. In a preferred embodiment, the bottom surface 1420 of the cavity 1404 is gold plated in order to optimally provide solderability.

In a preferred embodiment, the bottom surface 1420 further includes a recess 1422. The recess 1422 preferably includes a first wall 1424, a second wall 1426, a third wall 1428 and a fourth wall 1430. The first wall 1424 and the third wall 1428 are preferably approximately parallel to each other and the second wall 1426 and the fourth wall 1430 are preferably approximately parallel to each other. The second wall 1426 and the fourth wall 1430 are also preferably perpendicular to the first wall 1424 and the third wall 1428.

The recess 1422 preferably includes a bottom surface 1432. The length L_{1422} of the recess 1422 may range, for example, from about 110 to 130 mils. In a preferred embodiment, the length L_{1422} of the recess 1422 ranges from about 115 to 125 mils in order to optimally minimize thermal stresses. The width W_{1422} of the recess 1422 may range, for example, from about 110 to 130 mils. In a preferred embodiment the width W_{1422} of the recess 1422 ranges from about 115 to 125 mils in order to optimally minimize thermal stresses. The height H_{1422} of the recess 1422 may range, for example, from about1 to 2 mils. In a preferred embodiment, the height H_{1422} of the recess 1422 ranges from about 1.25 to 1.75 mils in order to optimally minimize thermal stresses. In a preferred embodiment, the recess 1422 is located approximately in the center of the bottom surface 1432 of the housing 1402. The first wall 1424 of the recess 1422 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1412 of the cavity 1404. In a preferred embodiment, the first wall 1424 of the recess 1422 is located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1412 of the cavity 1404 in order to optimally minimize thermal stresses. The second wall 1426 of the recess 1422 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1414 of the cavity 1404. In a preferred embodiment, the second wall 1426 of the recess 1422 is located a perpendicular distance ranging from about 85 to 95 mils from the second wall 1414 of the cavity 1404 in order to optimally minimize thermal stresses. The housing 1402 may, for example, be any number of conventional commercially available housings of the type ceramic, metal or plastic. In a preferred embodiment, the housing 1402 is ceramic in order to optimally provide good vacuum sealing. The bottom surface 1432 of the recess 1422 may, for example, be metal plated. In a preferred embodiment, the bottom surface 1432 of the recess 1422 is gold plated in order to optimally provide solderability.

The housing 1402 preferably includes a first planar surface 1406a, a second planar surface 1406b, a third planar surface 1406c, and a fourth planar surface 1406d. The first planar surface 1406a preferably includes one or more planar bond pads 1434. The planar bond pads 1434 are preferably approximately

rectangularly shaped. The planar bond pads 1434 are preferably used to wire-bond the controller 508 to the housing 1402. The number of planar bond pads 1434 preferably depend on having sufficient planar bond pads 1434 to connect the controller assembly 508 to the housing 1402. The second planar surface 1406b may, for example, be plated with a metal. In a preferred embodiment, the second planar surface 1406b is plated with gold in order to optimally provide solderability. The third planar surface 1406c may, for example, be plated with a metal. In a preferred embodiment, the third planar surface 1406c is plated with gold in order to optimally provide wire bonding. The fourth planar surface 1406d may, for example, be plated with metal. In a preferred embodiment, the fourth planar surface 1406d is plated with gold in order to optimally provide wire bonding. The resilient couplings 1306, the third planar surface 1406c and the fourth planar surface 1406d are preferably coupled to the one of the planar bond pads 1434 on the first planar surface 1406a by electrical paths molded into the housing 1402.

The housing 1402 preferably includes a plurality of first exterior surfaces 1408a and a plurality of second exterior surfaces 1408b. In a preferred embodiment, there are four first exterior surfaces 1408a and four second exterior surfaces 1408b forming an approximate octagon. The second exterior surfaces 1408b preferably couple the first exterior surfaces 1408a to each other. The first exterior surfaces 1408a include one or more exterior bond pads 1436 The exterior bond pads 1436 are preferably approximately rectangularly shaped. The exterior bond pads 1436 may, for example, be used for solder paste, solder balls, or leads attachment. In a preferred embodiment, the exterior bond pads 1436 are used to solder the sensor package 405 to the substrate 410. The number of exterior bond pads 1436 preferably depend on having sufficient exterior bond pads 1436 to connect the controller assembly 508 to the housing 1402. In an alternate embodiment, the exterior bond pads 1436 are on a single first exterior surface 1408a.

The bottom exterior surface 1410 of the housing 1402 preferably includes one or more bond pads 1438. The bond pads 1438 are preferably approximately circular in shape. The bond pads 1438 may be, for example, used for solder

paste, solder balls, or leads attachments. In a preferred embodiment, the bond pads 1438 are gold plated in order to optimally provide solderability. The number of bond pads 1438 preferably depend on having sufficient bond pads 1438 to connect the sensor module 405 to the substrate 410. The bond pads 1438 are preferably electrically coupled to the planar bond pads 1434 by electrical paths molded into the housing 1402. The exterior bond pads 1436 are preferably coupled to the planar bond pads 1434 by electrical paths molded into the housing.

The sensor 1304 is preferably resiliently attached to the housing 1402 by the resilient couplings 1306, slidingly supported by the sliding supports 1372, and electrically coupled to the housing 1402 by the electrical connections 510. In a preferred embodiment, there is the single approximately circular bond pad 1368a located in the approximate center of the sensor 1304.

The resilient couplings 1306 preferably resiliently attaches the bond pads 1368 to the housing 1402. The resilient couplings 1306 may electrically couple the sensor 1304 to the housing 1402. The resilient couplings 1306 are preferably coupled to the bottom surface 1432 of the recess 1422 of the cavity 1404 of the housing 1402. The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 2 to 7 mils from the first wall 1424 of the recess 1422 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 2 to 7 mils from the second wall 1426 of the recess 1422 of the cavity 1404 of the housing 1402. In a preferred embodiment, the resilient couplings 1306 are located a perpendicular distance ranging from about 3 to 5 mils from the first wall 1424 of the recess 1422 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a distance ranging from about 3 to 5 mils from the second wall 1426 of the recess 1422 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses. In a preferred embodiment, the resilient couplings 1306 are coupled to the bottom surface 1432 of the recess 1422 of the cavity 1404 of the housing 1402 using conventional solder equipment and processes. In a preferred embodiment, there is the single approximately circular resilient coupling 1306a located in the recess 1422 of the housing 1402.

The number of sliding supports 1372 preferably depends on having sufficient sliding supports 1372 to slidingly support the sensor 1302. In a preferred embodiment, the sliding supports 1372 preferably have an approximately square cross sectional shape. The sliding supports 1372 are preferably coupled to the bottom surface 1420 of the housing 1402. In a preferred embodiment, there is the first sliding support 1372a, the second sliding support 1372b, the third sliding support 1372c, and the fourth sliding support 1372d. The first sliding support 1372a is preferably located adjacent to one side of the resilient couplings 1306. The second sliding support 1372b is preferably located adjacent to the first sliding support 1372a. The third sliding support 1372c is preferably located adjacent to another side of the resilient couplings 1306. The fourth sliding support 1372d is preferably located adjacent to the third sliding support 1372c.

The first sliding support 1372a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1412 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1414 of the cavity 1404 of the housing 1402. In a preferred embodiment, the first sliding support 1372a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1412 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 1414 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses.

The second sliding support 1372b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1412 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1414 of the cavity 1404 of the housing 1402. In a preferred embodiment, the second sliding support 1372b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1412 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a perpendicular distance

ranging from about 20 to 25 mils from the second wall 1414 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses.

The third sliding support 1372c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1412 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1414 of the cavity 1404 of the housing 1402. In a preferred embodiment, the third sliding support 1372c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1412 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1414 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses.

The fourth sliding support 1372d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1412 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1414 of the cavity 1404 of the housing 1402. In a preferred embodiment, the fourth sliding support 1372d is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1412 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 1414 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 1372 are coupled to the bottom surface 1420 of the cavity 1404 of the housing 1402 using conventional means of integrating the sliding supports 1372 into the housing 1402.

The electrical connections 510 preferably electrically couple the sensor 1404 to the housing 1402. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 1406c of the housing 1402 to the top parallel planar surface 1354 of the sensor 1404. The second electrical connection 510b preferably electrically couples the fourth planar surface 1406d of the housing 1402 to the middle parallel planar surface

1356 of the sensor 1304. In a preferred embodiment, the electrical connections 510 are coupled to the housing 1402 using conventional wire bonding equipment and processes. In a preferred embodiment, the electrical connections 510 are coupled to the sensor 1304 using conventional wire bonding equipment and processes.

The lid assembly 506 is preferably coupled to the housing 1402. In a preferred embodiment, the length L_{572} of the lid 572 is at least 0.010 inches less than the length of the second planar surface 1406b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{572} of the lid 572 is at least 0.010 inches less than the width of the second planar surface 1406b in order to optimally provide good alignment tolerance. The bottom surface 576 of the lid 572 is preferably coupled to the housing 1402 via the solder preform 578. In a preferred embodiment, the outer length L_{578} of the solder preform 578 is at least 0.010 inches less than the outer length of the second planar surface 1406b in order to optimally provide good alignment tolerance. In a preferred embodiment, the exterior width W_{578} of the solder preform 578 is at least 0.010 inches less than the outer width of the second planar surface 1406b in order to optimally provide good alignment tolerance. The solder preform 578 is preferably coupled to the second planar surface 1406b of the housing 1402 using conventional solder equipment and processes. The solder preform 578 is preferably a rectangular ring that conforms to the shape of the second planar surface 1406b. The lid 572 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 1402, the sensor 1304, and the lid 506 are preferably vacuum-sealed to remove excess gas from the cavity 1404.

The controller assembly 508 is preferably coupled to the housing 1402. The lid 572 further includes a top surface 628. The adhesive 580 is preferably coupled to the top surface 628 of the lid 572. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 1434. The wire bonds 584 are coupled to the planar bond pads 1434 using conventional wire bonding equipment and processes. The controller assembly 508 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the recess 1422 is optional. The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1412 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1414 of the cavity 1404 of the housing 1402. In a preferred embodiment, the resilient couplings 1306 are located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1412 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a distance ranging from about 85 to 95 mils from the second wall 1414 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses.

In an alternate embodiment, the housing 1402 further includes circuit components. The circuit components may be integrated into the housing 1402, for example, on any of the planar surfaces 1406 or any of the first exterior surfaces 1408. In a preferred embodiment, the circuit components are integrated into the first planar surface 1406a in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 506 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 1372 are optional.

In an alternate embodiment, the getter 574 is optional.

In an alternate embodiment, the exterior bond pads 1436 are optional.

In several alternate embodiments, the bond pads 1368 may be one of the following: the bond pads 1368b, the bond pad 1368c, the bond pad 1368d, the bond pad 1368e, and the bond pad 1368f as referenced to in Figs. 13M through 13Q.

In an alternate embodiment, the resilient couplings 1306 may be the resilient couplings 1306b and 1306c as referenced to in Fig. 13V.

In several alternate embodiments, the sliding supports 1372 may be the sliding supports 1372e, 1372f, or 1372g as referenced to in Figs. 13W through 13Y.

Referring to Figs. 15A through 15L, an alternate embodiment of the sensor package 405 preferably includes the housing 1302, the sensor 1304, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 1302. The controller assembly 508 is preferably coupled to the bottom of the housing 1302. The sensor 1304 is preferably coupled within the housing 1302.

The housing 1302 is preferably coupled to the sensor 1304, the lid assembly 702, the controller assembly 508, the electrical connections 510, the sliding supports 1372, and the resilient couplings 1306.

The sensor 1304 is preferably resiliently attached to the housing 1302 by the resilient couplings 1306, slidingly supported by the sliding supports 1372, and electrically coupled to the housing 1302 by the electrical connections 510. In a preferred embodiment, there is the single approximately circular bond pad 1368a located in the approximate center of the sensor 1304.

The resilient couplings 1306 preferably resiliently attach the bond pads 1344 to the housing 1302. The resilient couplings 1306 may electrically couple the sensor 1304 to the housing 1302. The resilient couplings 1306 are preferably coupled to the bottom surface 1336 of the recess 1326 of the cavity 1308 of the housing 1302. In a preferred embodiment, there is the single approximately circular resilient coupling 1306a located in the recess 1326 of the housing 1302.

The number of sliding supports 1372 preferably depends on having sufficient sliding supports 1372 to slidingly support the sensor 1302. In a preferred embodiment, the sliding supports 1372 preferably have an approximately square cross sectional shape. The sliding supports 1372 are preferably coupled to the bottom surface 1324 of the housing 1302. In a preferred embodiment, there is the first sliding support 1372a, the second sliding support 1372b, the third sliding support 1372c, and the fourth sliding support 1372d. The first sliding support 1372a is preferably located adjacent to one side of the resilient couplings 1306. The second sliding support 1372b is preferably

located adjacent to the first sliding support 1372a. The third sliding support 1372c is preferably located adjacent to another side of the resilient couplings 1306. The fourth sliding support 1372d is preferably located adjacent to the third sliding support 1372c.

The electrical connections 510 preferably electrically couple the sensor 1304 to the housing 1302. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 1310c of the housing 1302 to the top parallel planar surface 1354 of the sensor 1302. The second electrical connection 510b preferably electrically couples the fourth planar surface 1310d of the housing 1302 to the middle parallel planar surface 1356 of the sensor 1302.

The lid assembly 702 is preferably coupled to the housing 1302. The lid assembly 702 preferably includes the lid 704, the getter 706 and the spring 708. The four arms 716 of the spring 708 preferably couple the bottom surface 710 of the lid 704 to the top planar surface 1354 of the sensor 1304. The spring 708 preferably secures the sensor 1304 to the resilient couplings 1306. The getter 706 is coupled to the bottom surface 710 of the lid 704 using conventional welding equipment and processes. In a preferred embodiment, the length L_{572} of the lid 572 may be at least 0.010 inches less than the length of the second planar surface 1310b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{572} of the lid 572 may be at least 0.010 inches less than the width of the second planar surface 1310b in order to optimally provide good alignment tolerance. The bottom surface 710 of the lid 704 is preferably coupled to the housing 1302 via the solder preform 578. In a preferred embodiment, the outer length L_{578} of the solder preform 578 may be at least 0.010 inches less than the outer length of the second planar surface 1310b in order to optimally provide good alignment tolerance. The lid 704 is coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 1302, the sensor 1304, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 1308.

The controller assembly 508 is preferably coupled to the bottom exterior surface 1314 of the housing 1302. The adhesive 580 is preferably coupled to the contact pad 1342. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 1344. The wire bonds 584 are preferably coupled to the bond pads 1344 using conventional wire bonding equipment and processes. The wire bonds 584 are preferably coupled to the controller 582 using conventional wire bonding equipment and processes. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the recess 1328 is optional. The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1316 of the cavity 1308 of the housing 1302 and may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1318 of the cavity 1308 of the housing 1302. In a preferred embodiment, the resilient couplings 1306 are located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1316 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses and located a distance ranging from about 85 to 95 mils from the second wall 1318 of the cavity 1308 of the housing 1302 in order to optimally minimize thermal stresses.

In an alternate embodiment, the housing 1302 further includes circuit components. The circuit components may be integrated into the housing 1302, for example, on any of the planar surfaces 1310 or any of the first exterior surfaces 1312a. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 1314 in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 1372 are optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the exterior bond pads 1340 are optional.

In several alternate embodiments, the bond pads 1368 may be one of the following: the bond pads 1368b, the bond pad 1368c, the bond pad 1368d, the bond pad 1368e, and the bond pad 1368f as referenced to in Figs. 13M through 13Q.

In an alternate embodiment, the resilient couplings 1306 may be the resilient couplings 1306b and 1306c as referenced to in Fig. 13V.

In several alternate embodiments, the sliding supports 1372 may be the sliding supports 1372e, 1372f, or 1372g as referenced to in Figs. 13W through 13Y.

Referring to Figs. 16A through 16L, an alternate embodiment of the sensor package 405 preferably includes the housing 1402, the sensor 1304, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 1402. The controller assembly 508 is preferably coupled to the top of the housing 1402. The sensor 1304 is preferably coupled within the housing 602.

The housing 1402 is preferably coupled to the sensor 1304, the lid assembly 702, the controller assembly 508, the electrical connections 510, the sliding supports 1372, and the resilient couplings 1306.

The sensor 1304 is preferably resiliently attached to the housing 1402 by the resilient couplings 1306, slidingly supported by the sliding supports 1372, and electrically coupled to the housing 1402 by the electrical connections 510. In a preferred embodiment, there is the single approximately circular bond pad 1368a located in the approximate of the sensor 1304.

The resilient couplings 1306 preferably resiliently attach the bond pads 1344 to the housing 1402. The resilient couplings 1306 may electrically couple the sensor 1304 to the housing 1402. The resilient couplings 1306 are preferably coupled to the bottom surface 1432 of the recess 1422 of the cavity 1404 of the housing 1402. In a preferred embodiment, there is the single approximately circular resilient coupling 1306a located in the recess 1422 of the housing 1402.

The number of sliding supports 1372 preferably depends on having sufficient sliding supports 1372 to slidingly support the sensor 1302. In a preferred embodiment, the sliding supports 1372 preferably have an approximately square cross sectional shape. The sliding supports 1372 are preferably coupled to the bottom surface 1420 of the housing 1402. In a preferred embodiment, there is the first sliding support 1372a, the second sliding support 1372b, the third sliding support 1372c, and the fourth sliding support 1372d. The first sliding support 1372a is preferably located adjacent to one side of the resilient couplings 1306. The second sliding support 1372b is preferably located adjacent to the first sliding support 1372a. The third sliding support 1372c is preferably located adjacent to another side of the resilient couplings 1306. The fourth sliding support 1372d is preferably located adjacent to the third sliding support 1372c.

The electrical connections 510 preferably electrically couple the sensor 1304 to the housing 1402. In a preferred embodiment, there is the first electrical connection 510a and the second electrical connection 510b. The first electrical connection 510a preferably electrically couples the third planar surface 1406c of the housing 1402 to the top parallel planar surface 1354 of the sensor 1304. The second electrical connection 510b preferably electrically couples the fourth planar surface 1406d of the housing 1402 to the middle parallel planar surface 1356 of the sensor 1304.

The lid assembly 702 is preferably coupled to the housing 1402. The lid assembly 702 preferably includes the lid 704, the getter 706 and the spring 708. In a preferred embodiment, the length L_{704} of the lid 704 may be at least 0.010 inches less than the length of the second planar surface 1406b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{704} of the lid 704 may be at least 0.010 inches less than the width of the second planar surface 1406b in order to optimally provide good alignment tolerance. The four arms 716 preferably couple the bottom surface 710 of the lid 704 to the top planar surface 1354 of the sensor 1304. The spring 708 preferably secures the sensor 1304 to the resilient couplings 1306. The getter 706 is coupled to the bottom surface 710 of the lid 704 using conventional welding equipment

and processes. The bottom surface 710 of the lid 704 is preferably coupled to the housing 1402 via the solder preform 578. In a preferred embodiment, the outer length L_{578} of the solder preform 578 may be at least 0.010 inches less than the outer length of the second planar surface 1406b in order to optimally provide good alignment tolerance. The lid 704 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 1402, the sensor 1304, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 1404.

The controller assembly 508 is preferably coupled to the top surface 712 of the lid 704. The adhesive 580 is preferably coupled to the top surface 712 of the lid 704. The controller 582 is preferably coupled to the adhesive 580. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 1434. The wire bonds 584 are preferably coupled to the planar bond pads 1434 using conventional wire bonding equipment and processes. The wire bonds 584 are preferably coupled to the controller 582 using conventional wire bonding equipment and processes. The controller 582 and the wire bonds 584 are preferably encapsulated with the encapsulant 586.

In an alternate embodiment, the recess 1422 is optional. The resilient couplings 1306 may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the first wall 1412 of the cavity 1404 of the housing 1402 and may be located a perpendicular distance ranging, for example, from about 80 to 100 mils from the second wall 1414 of the cavity 1404 of the housing 1402. In a preferred embodiment, the resilient couplings 1306 are located a perpendicular distance ranging from about 85 to 95 mils from the first wall 1412 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses and located a distance ranging from about 85 to 95 mils from the second wall 1414 of the cavity 1404 of the housing 1402 in order to optimally minimize thermal stresses.

In an alternate embodiment, the housing 1402 further includes circuit components. The circuit components may be integrated into the housing 1402, for example, on any of the planar surfaces 1406 or any of the first exterior surfaces 1408. In a preferred embodiment, the circuit components are integrated

into the first planar surface 1406a in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the sliding supports 1372 are optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the exterior bond pads 1436 are optional.

In several alternate embodiments, the bond pads 1368 may be one of the following: the bond pads 1368b, the bond pad 1368c, the bond pad 1368d, the bond pad 1368e, and the bond pad 1368f as referenced to in Figs. 13M through 13Q.

In an alternate embodiment, the resilient couplings 1306 may be the resilient couplings 1306b and 1306c as referenced to in Fig. 13V.

In several alternate embodiments, the sliding supports 1372 may be the sliding supports 1372e, 1372f, or 1372g as referenced to in Figs. 13W through 13Y.

Referring to Figs. 17A through 17J, an alternate embodiment of the sensor package 405 preferably includes a housing 1702, a sensor 1704, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 1702. The controller assembly 508 is preferably coupled to the bottom of the housing 1702. The sensor 1704 is preferably coupled within the housing 1702.

In a preferred embodiment, the packaging of the housing 1702, the sensor 1704, and the lid assembly 702 are the sensor package arrangement substantially as disclosed in copending U. S. Patent Application Serial No. 08/935,093, Attorney Docket No. IOS011, filed on September 25, 1997, the contents of which are incorporated herein by reference.

The housing 1702 is preferably coupled to the sensor 1704, the lid assembly 702, the controller assembly 508, and a spring assembly 1706. The

housing 1702 preferably includes a cavity 1708, one or more planar surfaces 1710, one or more exterior surfaces 1712, and a bottom exterior surface 1714. The cavity 1708 preferably includes a first wall 1716, a second wall 1718, a third wall 1720 and a fourth wall 1722. The first wall 1716 and the third wall 1720 are preferably approximately parallel to each other and the second wall 1718 and the fourth wall 1722 are preferably approximately parallel to each other. The second wall 1718 and the fourth wall 1722 are also preferably perpendicular to the first wall 1716 and the third wall 1720. The cavity 1708 preferably includes a bottom surface 1724. The bottom surface 1724 may, for example, be plated with metal. In a preferred embodiment, the bottom surface 1724 is gold plated in order to optimally provide a reliable electrical contact. The housing 1702 may, for example, be any number of conventional commercially available housings of the type ceramic, plastic or metal. In a preferred embodiment, the housing 1702 is ceramic in order to optimally provide vacuum sealing capability.

The housing 1702 preferably includes a first planar surface 1710a, a second planar surface 1710b, and a third planar surface 1710c. The first planar surface 1710a preferably includes one or more planar bond pads 1726. The planar bond pads 1726 are preferably approximately rectangularly shaped. The planar bond pads 1726 may, for example, be metal plated. In a preferred embodiment, the planar bond pads 1726 are gold plated in order to optimally provide solderability. The number of planar bond pads 1726 preferably depend on having sufficient planar bond pads 1726 to connect the sensor package 405 to the substrate 410. The second planar surface 1710b may, for example, be metal plated. In a preferred embodiment, the second planar surface 1710b is plated with gold in order to optimally provide solderability. The third planar surface 1710c may, for example, be metal plated. In a preferred embodiment, the third planar surface 1710c is plated with gold in order to optimally provide a reliable electrical connection.

The housing 1702 preferably includes a plurality of first exterior surfaces 1712a and a plurality of second exterior surfaces 1712b. In a preferred embodiment, there are four first exterior surfaces 1712a and four second exterior surfaces 1712b forming an approximate octagon. The second exterior surfaces

1712b preferably couple the first exterior surfaces 1712a to each other. The first exterior surfaces 1712a preferably include one or more exterior bond pads 1728. The exterior bond pads 1728 are preferably approximately rectangularly shaped. The exterior bond pads 1728 may, for example, be used for solder paste, solder balls or leads attachments. In a preferred embodiment, the exterior bond pads 1728 are used to solder the sensor package 405 to the substrate 410. The number of exterior bond pads 1728 preferably depend on having sufficient exterior bond pads 1728 to connect the sensor package 405 to the substrate 410.

The bottom exterior surface 1714 preferably includes a contact pad 1730, one or more bond pads 1732, and one or more connecting pads 1734. The contact pad 1730 may, for example, be metal plated. In a preferred embodiment, the contact pad 1730 is gold-plated in order to optimally provide a reliable electrical connection. The planar bond pads 1726 from the first planar surface 1710a are preferably electrically coupled to the bond pads 1732 on the bottom exterior surface 1714 by electrical paths molded into the housing 1702. The second planar surface 1710b, the third planar surface 1710c, and the bottom surface 1724 are preferably coupled to one or more bond pads 1732, on the bottom exterior surface 1714, by electrical paths molded into the housing 1702. The bond pads 1732 may, for example, be metal plated. In a preferred embodiment, the bond pads 1732 are gold plated in order to optimally provide wire bonding. The number of bond pads 1732 preferably depend on having sufficient bond pads 1732 to connect the controller assembly 508 to the housing 1702. The connecting pads 1734 may, for example, be metal plated. In a preferred embodiment, the wiring pads 1734 are gold-plated in order to optimally provide a conductive pathway between the bond pads 1732 and the contact pad 1730. In a preferred embodiment, there is a first connecting pad 1734a and a second connecting pad 1734b. The exterior bond pads 1728 are preferably electrically coupled to the bond pads 1732 by electrical paths molded into the housing 1702.

The sensor 1704 is preferably coupled to the bottom surface 1724 of the housing 1702. The sensor 1704 preferably has an approximately rectangular cross-sectional shape. In a preferred embodiment, the sensor 1704 includes a first member 1736, a second member 1738, and a third member 1740. The first

member 1736 is preferably on top of the second member 1738 and the second member 1738 is preferably on top of the third member 1740. In a preferred embodiment, the first member 1736, the second member 1738, and the third member 1740 are a micro machined sensor substantially as disclosed in copending U. S. Patent Application Serial No. ________, Attorney Docket No. 14737.737, filed on ___________, the contents of which are incorporated herein by reference.

The first member 1736 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the first member includes a top parallel planar surface 1742. The second member 1738 preferably includes one or more parallel planar surfaces. In a preferred embodiment, the second member 1738 includes a first middle parallel planar surface 1744 and a second middle parallel planar surface 1746.

The sensor 1704 is preferably coupled to the housing via the spring assembly 1706 and a shorting clip 1748. The spring assembly 1706 is preferably fabricated from one piece of spring material which is bent into a middle spring member 1750, a side spring member 1752 and a side support member 1754. The middle spring member 1750 is preferably approximately perpendicular to both the side spring member 1752 and the side support member 1754. The middle spring member 1750 preferably has a flat top surface 1756 that curls down to a loop 1758. The side spring member 1752 preferably has a flat top surface 1760 that curls down to a loop 1762. The side support member 1754 has a flat top surface 1764 that bends down at a right angle.

The spring assembly 1706 is preferably inserted into the cavity 1708. The middle spring member 1750 flat top surface 1756, the side spring member 1752 flat top surface 1760, and the side support member 1754 flat top surface 1764 are preferably coupled to the third planar surface 1710c of the housing 1702. In a preferred embodiment, the spring assembly 1706 is welded to the third planar surface 1710c of the housing 1702 in order to optimally provide mechanical and electrical connection to the sensor 1704. The middle spring member 1750 loop 1758 and the side spring member 1752 loop 1762 preferably secure the sensor 1704 within the cavity 1708 of the housing 1702.

The shorting clip 1748 preferably extends around the first middle planar surface 1744 of the sensor 1704 and the second middle planar surface 1746 of the sensor 1704. The shorting clip 1748 preferably contacts the spring assembly 1706 securing the sensor 1704 within the cavity 1708 of the housing 1702 providing a conductive pathway between the center member 1738 of the sensor 1704, to the third planar surface 1710c of the housing 1702. The shorting clip 1748 may, for example, be fabricated from about 0.003 inch stainless steel or beryllium copper strip. In a preferred embodiment, the shorting clip 1748 is stainless steel in order to optimally provide good mechanical strength and stable properties.

The lid assembly 702 is preferably coupled to the housing 1702. In a preferred embodiment, the length L_{704} of the lid 704 may be at least 0.010 inches less than the length of the second planar surface 1406b in order to optimally provide good alignment tolerance. In a preferred embodiment, the width W_{704} of the lid 704 may be at least 0.010 inches less than the width of the second planar surface 1710b in order to optimally provide good alignment tolerance. The spring 708 is preferably welded to the bottom surface 710 of the lid 704 and the four arms 716 preferably couple the bottom surface 710 of the lid 704 to the top parallel planar surface 1742 of the sensor 1704. The spring 708 preferably secures the sensor 1704 to the bottom surface 1724 of the cavity 1708. The bottom member 1740 preferably electrically couples the sensor 1704 to the housing 1702 via the bottom surface 1724. The getter 706 is preferably coupled to the bottom surface 710 of the lid 704 using conventional welding equipment and processes. The bottom surface 710 of the lid 704 is preferably coupled to the housing 1702 via the solder preform 578. In a preferred embodiment, the outer length L_{578} of the solder preform 578 may be at least 0.010 inches less than the outer length of the second planar surface 1710b in order to optimally provide good alignment tolerance. The lid 704 is preferably coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 1702, the sensor 1704, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 1708. The lid 704 preferably electrically couples the housing 1702 to the sensor 1704 via the spring 708.

The controller assembly 508 is preferably coupled to the bottom exterior surface 1714 of the housing 1702. The adhesive 580 is preferably coupled to the contact pad 1730 on the bottom exterior surface of the housing 1702. The wire bonds 584 are preferably coupled to the controller 582 and the bond pads 1732. The wire bonds 584 are preferably coupled to the bond pads 1732 using conventional wire bonding equipment and processes. The wire bonds 584 are coupled to the controller 582 using conventional wire bonding equipment and processes.

In an alternate embodiment, the housing 1702 further includes circuit components. The circuit components may be integrated into the housing 1702, for example, on any of the planar surfaces 1710 or any of the first exterior surfaces 1712. In a preferred embodiment, the circuit components are integrated into the bottom exterior surface 1714 in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the exterior bond pads 1728 are optional.

In an alternate embodiment, the housing 1702 further includes the sliding supports 1372. The number of sliding supports 1372 preferably depends on having sufficient sliding supports 1372 to slidingly support the sensor 1704. In a preferred embodiment, the sliding supports 1372 preferably have an approximately square cross sectional shape. The sliding supports 1372 are preferably coupled to the bottom surface 1724 of the housing 1702. In a preferred embodiment, there is the first sliding support 1372a, the second sliding support 1372b, the third sliding support 1372c, and the fourth sliding support 1372d.

The first sliding support 1372a may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1716 of the

cavity 1708 of the housing 1702 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1718 of the cavity 1708 of the housing 1702. In a preferred embodiment, the first sliding support 1372a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1716 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 1718 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses.

The second sliding support 1372b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1716 of the cavity 1708 of the housing 1702 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1718 of the cavity 1708 of the housing 1702. In a preferred embodiment, the second sliding support 1372b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1716 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1718 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses.

The third sliding support 1372c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1716 of the cavity 1708 of the housing 1702 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1718 of the cavity 1708 of the housing 1702. In a preferred embodiment, the third sliding support 1372c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1716 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1718 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses.

The fourth sliding support 1372d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1716 of the cavity 1708 of the housing 1702 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1718 of the

cavity 1708 of the housing 1702. In a preferred embodiment, the fourth sliding support 1372b is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1716 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 1718 of the cavity 1708 of the housing 1702 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 1372 are coupled to the bottom surface 1724 of the cavity 1708 of the housing 1702 using conventional means of integrating the sliding supports 1372 into the housing 1702.

In several alternate embodiments, the sliding supports 1372 may be the sliding supports 1372e, 1372f, or 1372g as referenced to in Figs. 13W through 13Y.

Referring to Figs. 18A through 18J, an alternate embodiment of the sensor package 405 preferably includes a housing 1802, the sensor 1704, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 1802. The controller assembly 508 is preferably coupled to the top of the housing 1802. The sensor 1704 is preferably coupled within the housing 1802.

In a preferred embodiment, the packaging of the housing 1802, the sensor 1704, and the lid assembly 702 are the sensor package arrangement substantially as disclosed in copending U. S. Patent Application Serial No. 08/935,093, Attorney Docket No. IOS011, filed on September 25, 1997, the contents of which are incorporated herein by reference.

The housing 1802 is preferably coupled to the sensor 1704, the lid assembly 702, the controller assembly 508, and the spring assembly 1706. The housing preferably includes a cavity 1804 , one or more planar surfaces 1806, one or more exterior surfaces 1808, and a bottom exterior surface 1810. The cavity 1804 preferably includes a first wall 1812, a second wall 1814, a third wall 1816 and a fourth wall 1818. The first wall 1812 and the third wall 1816 are preferably approximately parallel to each other and the second wall 1814 and the fourth wall 1818 are preferably approximately parallel to each other. The second wall 1814 and the fourth 1818 wall are also preferably perpendicular to the first

wall 1812 and the third wall 1816. The cavity 1804 preferably includes a bottom surface 1820. The bottom surface 1820 may, for example, be metal plated. In a preferred embodiment, the bottom surface 1820 is gold plated in order to optimally provide a reliable electrical contact. The housing 1802 may, for example, be any number of conventional commercially available housings of the type ceramic, plastic or metal. In a preferred embodiment, the housing 1802 is ceramic in order to optimally provide vacuum sealing capability.

The housing 1802 preferably includes a first planar surface 1806a, a second planar surface 1806b, and a third planar surface 1806c. The first planar surface 1806a preferably includes one or more planar bond pads 1822. The planar bond pads 1822 are preferably approximately rectangularly shaped. The planar bond pads 1822 may, for example, be metal plated. In a preferred embodiment, the planar bond pads 1822 are gold in order to optimally provide good wire bonding. The planar bond pads 1822 are preferably used for wire-bonding the controller 508 to the housing 1802. The third planar surface 1806c may, for example, be metal plated. In a preferred embodiment, the third planar surface 1806c is plated with gold in order to optimally provide wire bonding. The second planar surface 1806b, the third planar surface 1806c, and the bottom surface 1820 are preferably coupled to the one of the planar bond pads 1822 on the first planar surface 1806a by electrical paths molded into the housing 1802.

The housing 1802 preferably includes a plurality of first exterior surfaces 1808a and a plurality of second exterior surfaces 1808b. In a preferred embodiment, there are four first exterior surfaces 1808a and four second exterior surfaces 1808b forming an approximate octagon. The second exterior surfaces 1808b preferably couple the first exterior surfaces 1808a to each other. The first exterior surfaces 1808a include one or more exterior bond pads 1824. The exterior bond pads 1824 are preferably approximately rectangularly shaped. The exterior bond pads 1824 may, for example, be used for solder paste, solder balls or leads attachment. In a preferred embodiment, the exterior bond pads 1824 are used to solder the sensor packages 405 to the substrate 410. The number of exterior bond pads 1824 preferably depend on having sufficient exterior bond pads 1824 to connect the sensor package 405 to the substrate 410. The exterior

bond pads 1824 are preferably electrically coupled to the planar bond pads 1822 via electrical paths molded into the housing 1802.

The bottom exterior surface 1810 preferably includes one or more bond pads 1826. The bond pads 1826 are preferably approximately circular in shape. The bond pads 1826 may be, for example, used for solder paste, solder balls, or leads attachments. In a preferred embodiment, the bond pads 1826 are gold plated in order to optimally provide solderability. The number of bond pads 1826 preferably depend on having sufficient bond pads 1826 to connect the sensor module 405 to the substrate 410. The exterior bond pads 1824 are preferably electrically connected to the bond pads 1826 via electrical paths molded into the housing 1802.

The sensor 1704 is preferably coupled to the bottom surface 1820 of the housing 1802. The sensor 1704 is preferably coupled to the housing 1802 via the spring assembly 1706 and the shorting clip 1748. The spring assembly 1706 is preferably inserted into the cavity 1804. The middle spring member 1750 flat top surface 1756, the side spring member 1752 flat top surface 1760, and the side support member 1754 flat top surface 1764 are preferably coupled to the third planar surface 1806c of the housing 1802. In a preferred embodiment, the spring assembly 1706 is welded to the third planar surface 1806c of the housing 1802 in order to optimally provide mechanical and electrical connections to the sensor 1704. The middle spring member 1750 loop 1758 and the side spring member 1752 loop 1762 preferably secure the sensor 1704 within the cavity 1804 of the housing 1802.

The shorting clip 1748 preferably extends around the first middle planar surface 1744 of the sensor 1704 and the second middle planar surface 1746 of the sensor 1704. The shorting clip 1748 preferably contacts the spring assembly 1706 securing the sensor 1704 within the cavity 1804 of the housing 1802 providing a conductive pathway between the center member 1738 of the sensor 1704, to the third planar surface 1806c of the housing 1802. The shorting clip 1748 may, for example, be fabricated from about 0.003 inch stainless steel or beryllium copper strip. In a preferred embodiment, the shorting clip 1748 is

stainless steel in order to optimally provide good mechanical strength and stable properties.

The lid assembly 702 is preferably coupled to the housing 1802. In a preferred embodiment, the width W_{704} of the lid 704 may be at least 0.010 inches less than the width of the second planar surface 1806b in order to optimally provide good alignment tolerance. The four arms 716 preferably couple the bottom surface 710 of the lid 704 to the top planar surface 1742 of the sensor 1704. The bottom surface 710 of the lid 704 is preferably coupled to the housing 1802 via the solder preform 578. In a preferred embodiment, the outer length L_{578} of the solder preform 578 may be at least 0.010 inches less than the outer length of the second planar surface 1806b in order to optimally provide good alignment tolerance. The spring 708 is preferably welded to the bottom surface 710 of the lid 704 and the four arms 716 preferably couple the bottom surface 710 of the lid 704 to the top parallel planar surface 1742 of the sensor 1704. The spring 708 preferably secures the sensor 1704 to the bottom surface 1820 of the cavity 1804. The bottom member 1740 preferably electrically couples the sensor 1704 to the housing 1802 via the planar bond pads 18223. The lid 704 is coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 1802, the sensor 1704, and the lid assembly 702 are preferably vacuum-sealed to remove excess gas from the cavity 1804.

The controller assembly 508 is preferably coupled to the top surface 712 of the lid 704. The adhesive 580 is preferably coupled to the top surface 712 of the lid 704. The wire bonds 584 are preferably coupled to the controller 582 and the planar bond pads 1822. The controller assembly 508 preferably includes a first wire bond 584a and a second wire bond 584b. The first wire bond 584a preferably couples the first planar bond pad 1822a to the controller 582. The second wire bond 584b preferably couples the second planar bond pad 1822b to the controller 582. The wire bonds 584 are coupled to the planar bond pads 1822 using conventional wire bonding equipment and processes. The wire bonds 584 are coupled to the controller 582 using conventional wire bonding equipment and processes.

In an alternate embodiment, the housing 1802 further includes circuit components. The circuit components may be integrated into the housing 1802, for example, on any of the planar surfaces 1806 or any of the first exterior surfaces 1808. In a preferred embodiment, the circuit components are integrated into the first planar surface 1806a in order to optimally reduce the size of the sensor module 405. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally reduce system 100 size.

In an alternate embodiment, the lid assembly 702 is optional.

In an alternate embodiment, the controller assembly 508 is optional.

In an alternate embodiment, the getter 706 is optional.

In an alternate embodiment, the exterior bond pads 1824 are optional.

In an alternate embodiment, the housing 1802 further includes the sliding supports 1372. The number of sliding supports 1372 preferably depends on having sufficient sliding supports 1372 to slidingly support the sensor 1704. In a preferred embodiment, the sliding supports 1372 preferably have an approximately square cross sectional shape. The sliding supports 1372 are preferably coupled to the bottom surface 1820 of the housing 1802. In a preferred embodiment, there is the first sliding support 1372a, the second sliding support 1372b, the third sliding support 1372c, and the fourth sliding support 1372d.

The first sliding support 1372a may be located a perpendicular distance ranging, for example, from about45 to 75 mils from the first wall 1812 of the cavity 1804 of the housing 1802 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1814 of the cavity 1804 of the housing 1802. In a preferred embodiment, the first sliding support 1372a is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1812 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses and located a perpendicular distance from about 90 to 105 mils from the second wall 1814 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses.

The second sliding support 1372b may be located a perpendicular distance ranging, for example, from about 45 to 75 mils from the first wall 1812 of the cavity 1804 of the housing 1802 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1814 of the cavity 1804 of the housing 1802. In a preferred embodiment, the second sliding support 1372b is located a perpendicular distance ranging from about 52 to 62 mils from the first wall 1812 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1814 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses.

The third sliding support 1372c may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1812 of the cavity 1804 of the housing 1802 and may be located a perpendicular distance ranging, for example, from about 15 to 30 mils from the second wall 1814 of the cavity 1804 of the housing 1802. In a preferred embodiment, the third sliding support 1372c is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1812 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 20 to 25 mils from the second wall 1814 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses.

The fourth sliding support 1372d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 1812 of the cavity 1804 of the housing 1802 and may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the second wall 1814 of the cavity 1804 of the housing 1802. In a preferred embodiment, the fourth sliding support 1372b is located a perpendicular distance ranging from about 90 to 105 mils from the first wall 1812 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses and located a perpendicular distance ranging from about 90 to 105 mils from the second wall 1814 of the cavity 1804 of the housing 1802 in order to optimally minimize thermal stresses. In a preferred embodiment, the sliding supports 1372 are coupled to the bottom

surface 1820 of the cavity 1804 of the housing 1802 using conventional means of integrating the sliding supports 1372 into the housing 1802.

In several alternate embodiments, the sliding supports 1372 may be the sliding supports 1372e, 1372f, or 1372g as referenced to in Figs. 13W through 13Y.

Referring to Fig. 19, an alternate embodiment of the sensor module 305 preferably includes the sensor packages 405, a substrate 410, and a monolithic package 1902. The sensor packages 405 are preferably coupled to the monolithic package 1902. In a preferred embodiment, the sensor module 305 includes a first sensor package 405a, a second sensor package 405b, and a third sensor package 405c. The first sensor package 405a preferably includes an axis of sensitivity 415. The axis of sensitivity 415 is preferably approximately parallel to the x-axis. The first sensor package 405a is preferably coupled to the monolithic package 1902 to maintain the axis of sensitivity 415 parallel to the x-axis. The second sensor package 405b preferably includes an axis of sensitivity 420. The axis of sensitivity 420 is preferably approximately parallel to the y-axis. The second sensor package 405b is preferably coupled to the monolithic package 1902 to maintain the axis of sensitivity 420 parallel to the y-axis. The third sensor package 405c preferably includes an axis of sensitivity 425. The axis of sensitivity 425 is preferably approximately parallel to the z-axis. The third sensor package 405c is preferably coupled to the monolithic package 1902 to maintain the axis of sensitivity 425 parallel to the z-axis.

The sensor packages 405 may, for example, be coupled to the monolithic package 1902 using one of the following methods: integrated as part of the monolithic package 1902, rigidly attached to the monolithic package 1902, or removably attached to the monolithic package 1902. In a preferred embodiment, the sensor packages 405 are coupled to the monolithic package 1902 by removably attaching the sensor packages 405 into the monolithic package 1902 in order to optimally provide cost-effectiveness and good manufacturability. In several alternate embodiments, the removable attachment methods include socketing, screw attaching or other mechanical attachment methods.

The monolithic package 1902 may, for example, be plastic, ceramic, or metal. In a preferred embodiment, the monolithic package 1902 is plastic in order to optimally provide ease of manufacturing and cost effectiveness. The monolithic package 1902 may be, for example, a hollow frame, a box, a three-dimensional circuit board, a cylinder, or a cube. The monolithic package 1902 is preferably coupled to the substrate 410. The monolithic package 1902 may, for example, be coupled to the substrate 410 using one of the following methods: solder-paste surface mount, solder-ball, leads, connectors, epoxies, mechanical connections or wire bonding. The monolithic package 1902 is preferably coupled to the substrate 410 by leads in order to optimally provide cost effectiveness and good manufacturability.

In several alternate embodiments, rigidly attaching the sensor packages 405 to the monolithic package 1902 includes using solder, epoxies, or glass frit bonding.

In several alternate embodiments, the monolithic package 1902 includes recesses adapted to receive the sensor packages 405.

In several alternate embodiments, the sensor packages 405 may be the sensors 504, 902, 1304, or 1704 as described above with reference to Figs. 5B, 9B,13B and 17B. The sensors 504, 902, 1304, or 1704 may be coupled to the monolithic package 1902 by the methods substantially as disclosed in copending U. S. Patent Application Serial No. _________, Attorney Docket No. 14737.743, filed on ____________, the contents of which are incorporated herein by reference. In an alternate embodiment, the sensors 504, 902, 1304, or 1704 are further vacuum-sealed into the monolithic package 1902.

Referring to Fig. 20, an alternate embodiment of the sensor module 305 includes one or more sensor packages 405. The sensor packages 405 are preferably coupled to each other. In a preferred embodiment, the sensor module 305 includes the first sensor package 405a, the second sensor package 405b, and the third sensor package 405c. The first sensor package 405a preferably includes an axis of sensitivity 415. The axis of sensitivity 415 is preferably approximately parallel to the x-axis. The first sensor package 405a is preferably coupled to the second sensor package 405b to maintain the axis of sensitivity 415 parallel to the

x-axis. The second sensor package 405b preferably includes an axis of sensitivity 420. The axis of sensitivity 420 is preferably approximately parallel to the y-axis. The second sensor package 405b is preferably coupled to the first sensor package 405a and the third sensor package 405c to maintain the axis of sensitivity 420 parallel to the y-axis. The third sensor package 405c preferably includes an axis of sensitivity 425. The axis of sensitivity 425 is preferably approximately parallel to the z-axis. The third sensor package 405c is preferably coupled to the second sensor package 405b to maintain the axis of sensitivity 425 parallel to the z-axis. The sensor packages 405 may, for example, be coupled to each other using one of the following methods: solder, epoxy, or mechanical attachment. In a preferred embodiment, the sensor packages 405 are coupled to each other by solder in order to optimally provide good manufacturability.

Referring to Figs. 21A through 21C, in an alternate embodiment, the sensor package 405 preferably includes one or more substrates 2102 and one or more sensors 2118. The substrates 2102 are preferably coupled to the sensors 2118.

The substrates 2102 may be, for example, ceramic, PC-board or silicon. In a preferred embodiment, there is a single substrate 2102. The substrate 2102 preferably includes a top planar surface 2128 and a bottom planar surface 2130. The top planar surface 2128 preferably includes one or more traces 2104. The bottom planar surface preferably includes one or more traces 2104. The traces 2104 may be, for example, aluminum, copper or gold. In a preferred embodiment, the traces 2104 are gold in order to optimally provide conductivity and solder interconnection. The number of traces 2104 preferably depends on having sufficient traces 2104 to couple the sensor 2118 to the package 2102.

The substrate 2102 preferably further includes one or more slots 2106. The slots 2106 preferably include a first wall 2108, a second wall 2110, a third wall 2112, and a fourth wall 2114. The first wall 2108 and the third wall 2112 are preferably approximately parallel to each other and the second wall 2110 and the fourth wall 2114 are preferably approximately parallel to each other. The second wall 2110 and the fourth 2114 wall are also preferably perpendicular to the first wall 2108 and the third wall 2112. The slots 2106 are preferably

adapted to receive the sensors 2118. The length of the slot L_{2106} may range, for example, from about 5000 to 15000 microns. In a preferred embodiment, the length of the slot L_{2106} ranges from about 5000 to 7000 microns in order to optimally provide vertical alignment. The width of the slot W_{2106} may range, for example, from about 500 to 2000 microns. In a preferred embodiment, the width of the slot W_{2106} ranges from about 1000 to 1200 microns in order to optimally provide vertical alignment.

The sensors 2118 are preferably coupled to the substrate 2102. The sensors 2118 preferably have an approximately rectangular cross-sectional shape. In a preferred embodiment, the sensors 2118 includes a first member 2120, a second member 2122, and a third member 2124. The first member 2120 is preferably on top of the second member 2122 and the second member 2122 is preferably on top of the third member 2124. In a preferred embodiment, the first member 2120, the second member 2122, and the third member 2124 are a micro machined sensor substantially as disclosed in copending U. S. Patent Application Serial No. _________, Attorney Docket No. 14737.737, filed on ____________, the contents of which are incorporated herein by reference.

The sensors 2118 preferably further include an axis of sensitivity 2132. The sensors 2118 are preferably coupled to substrate 2102 to maintain the axis of sensitivity 2132 parallel to the substrate 2102. The second member 2122 preferably has an extended tab 2116. The extended tab 2116 is preferably adapted to insert into the slots 2106 of the substrate 2102. The sensors 2122 are preferably resiliently coupled to the substrate 2102 by one or more connections 2126. The connections 2126 may be, for example, micro-welding, solder pastes or conductive adhesive. In a preferred embodiment, the connections 2126 are solder paste in order to optimally provide tensile strength. The solder pastes 2126 may be, for example, of the type eutectic or non-eutectic. In a preferred embodiment, the solder pastes 2126 are eutectic in order to optimally provide temperature hierarchy and tensile strength. The solder pastes 2126 preferably couple one or more traces 2104 to the sensor 2122. In a preferred embodiment, there is a first trace 2104a, a second trace 2104b, a third trace 2104c and a fourth trace 2104d. The first trace 2104a is preferably located on the top planar surface

2128 and is preferably coupled to the first member 2120. The second trace 2104b is preferably located on the top planar surface 2128 and is preferably coupled to the third member 2124. The third trace 2104c may be, for example, a redundant connection to the second member 2122 or not used. The fourth trace 2104d is preferably located on the bottom planar surface 2130 and is preferably coupled to second member 2122.

Referring to Fig. 21D, in an alternate embodiment, the sensor package 405 as referenced to in Figs. 21A through 21C, includes a first substrate 2102a and a second substrate 2102b. The second substrate preferably includes a top planar surface 2154 and a bottom planar surface 2156. The third trace 2104c and the fourth trace 2104d may be coupled to the second substrate 2102b, for example, by solder paste, conductive epoxy, or wafer bonding techniques. The fourth trace 2104d may be located on the top planar surface 2154 of the second substrate 2102b or on the bottom planar surface 2130 of the first substrate 2102a. The fourth trace 2104d preferably couples the second member 2122 to a bond pad 2150. The bond pad 2150 may be coupled to a bond wire 2152. The sensor package 405 may be surface or flush mounted. The sensor 2118 preferably has one or more leads coming from the first member 2120 and the third member 2124. The substrate 2102b preferably acts like a mechanical spacer.

Referring to Figs. 22A through 22D, in several alternate embodiments, the housings 502, 602, 1302, and 1402, as described above with reference to Figs. 5B, 6B, 13B and 14B, include one or more pedestals 2202a or 2202b for supporting one or more resilient couplings. The pedestals 2202a and 2202b may be fabricated from, for example, tungsten or ceramic. In a preferred embodiment, the pedestals 2202a and 2202b are fabricated from ceramic. The height H_{2202} of the pedestals 2202a and 2202b may range, for example, from about 0 to 10 mils. In a preferred embodiment, the height H_{2202} of the pedestals 2202a and 2202b is approximately 5 mils. The pedestal 2202a is preferably a rectangular shaped support pipe. The pedestal 2202a preferably has straight edges. In an alternate embodiment, the pedestal 2202b is a cylindrical section. The pedestal 2202b preferably has tapered sides. In an alternate embodiment, the pedestal 2202b has straight sides. In a preferred embodiment, the pedestals 2202a and 2202b

have a shape that optimally minimizes the thermal stresses between the pedestals 2202a and 2202b and the resilient couplings it supports.

Referring to Figs. 23A and 23B, in an alternate embodiment, the sensor module 305 includes the substrate 2102 and one or more sensors 2118. In a preferred embodiment, there is a first sensor 2118a, a second sensor 2118b, and a third sensor 2118c. The first sensor 2118a and the second sensor 2118b are preferably inserted into one or more slots 2106 and resiliently coupled to the substrate 2102 by one or more solder pastes 2126 as previously described above with reference to Figs. 21A through 21D. The third sensor 2118c is resiliently coupled to the substrate 2102 using any of the resilient couplings 512, 904 or 1306 as previously described above with reference to Figs. 5C, 9C or 13C. The third sensor 2118c is also slidingly supported by the sliding supports 514, 940, or 1372 as previously described above with reference to Figs. 5C, 9C or 13C. In an alternate embodiment, the sliding supports 514, 940, or 1372 are optional.

Referring to Fig. 24, in several alternate embodiments of the sensor package 405, the housings 502, 602, 1302, 1402, 1702 and 1802, as described above with reference to Figs. 5B, 6B, 13B, 14B, 17B, and 18B, further include a cavity 2402 preferably adapted to receive the controller 582. The housings 502 and 1302 further include one or more external planar surfaces 2404. In a preferred embodiment, there is a first external planar surface 2404a, a second external planar surface 2404b, and a third external planar surface 2404c. The second external planar surface 2404b preferably includes the bond pads 540, 622, 1344, and 1434 as described above with reference to Figs. 5E, 6C, 13E, and 14C. The cavity 2402 preferably includes a first wall 2406a, a second wall 2406b, a third wall 2406c, and a fourth wall 2406d. The first wall 2406a and the third wall 2406c are preferably approximately parallel to each other and the second wall 2406b and the fourth wall 2406d are preferably approximately parallel to each other. The second wall 2406b and the fourth wall 2406d are also preferably perpendicular to the first wall 2406a and the third wall 2406c. The controller 582 may be coupled to the third external planar surface 2404c, for example, by solder or epoxy. The wire bonds 584 preferably couple the controller 582 to the second external planar surface 2404b. A lid 2408 preferably encloses the

controller 582, the wire bonds 584, and the cavity 2402. The lid 2408 is preferably coupled to the first external planar surface 2404a. The lid 2408 preferably includes solder preforms 2410. The solder preforms 2410 are preferably coupled to the first external planar surface 2404a using conventional soldering equipment and processes.

Referring to Figs. 25A and 25B, in several alternate embodiments, the controller assembly 508 includes the adhesive 580, the controller 582, the wire bonds 584, and a hermetic cap 2502. The hermetic cap 2502 may be, for example, of the type ceramic or metal. In a preferred embodiment, the hermetic cap 2502 is metal in order to optimally provide good hermetic sealing. The hermetic cap 2502 is coupled to the housings 502, 602, 1302, 1402, 1702 and 1802 as described above with reference to Figs. 5B, 6B, 13B, 14B, 17B and 18B. The hermetic cap 2502 may be, for example, press-fit, epoxied, soldered or seam-sealed to the housings 502, 602, 1302, 1402, 1702 and 1802. In a preferred embodiment, the hermetic cap 2502 is soldered to the housings 502, 602, 1302, 1402, 1702 and 1802 in order to optimally provide good hermetic sealing.

Referring to Figs. 26A and 26B, in an alternate embodiment, the sensor package 405 includes the controller 582 preferably coupled to the housings 502, 602, 1302, 1402, 1702 and 1802, as described above with reference to Figs. 5B, 6B, 13B, 14B, 17B and 18B, by one or more connections 2602. The connections 2602 may be, for example, leads, solder, conductive epoxy, or ball-grid arrays. The controller 582 is preferably an integrated chip industry-standard package. The integrated chip industry-standard package may be, for example, ceramic or plastic.

Referring to Figs. 27A and 27B, in an alternate embodiment, the sensor package 405 includes a substrate 2702. The controller 582 is coupled to the substrate 2702. The substrate 2702 is coupled to the controller 582 by one or more electrical attachments 2704. The substrate 2702 may be, for example, ceramic or organic. The substrate 2702 is also coupled to the housings 502, 602, 1302, 1402, 1702, and 1802, as described above with reference to Figs. 5B, 6B, 13B, 14B, 17B and 18B, by one or more electrical attachments 2704. The electrical attachments 2704 may be, for example, leads, solder, conductive epoxy,

or ball grid arrays. The controller 582 may be, for example, an application specific integrated circuit die or an integrated chip industry standard package with connections. The integrated chip industry standard package may be, for example, ceramic or plastic. The solder attachments 2704 may be, for example, leads, solder, conductive epoxy, or ball-grid arrays. The substrate 2702 further includes conventional means of lead out, for example, leads, connectors or solder joints.

In an alternate embodiment, the substrate 2702 further includes circuit components. The circuit components may be, for example, filtering capacitors, resistors, or active components. In a preferred embodiment, the circuit components are filtering capacitors in order to optimally provide reduced system 100 size.

In several alternate embodiments, the housings 502 and 602, as described above with reference to Figs. 5B and 6B, include one or more recesses 1326, for receiving one or more resilient couplings substantially as described above with reference to Fig. 13B.

In several alternate embodiments, the cavities 516, 604, 1308, 1404, 1708, and 1804, as described above with reference to Figs. 5B, 6B, 7B, 8B, 9B, 10B, 11B, 12B, 13B, 14B, 15B, 16B, 17B, and 18B, may be further filled with other materials. The materials may be, for example, gels or molded plastics.

In several alternate embodiments, splitting the resilient attachment of the sensor 504, 902, and 1304, as described above with reference to Figs. 5B, 9B, and 13B, to the housing 502, 602, 1302, and 1402, as described above with reference to Figs. 5B, 6B, 13B, and 14B, reduces the stress from the attachment.

In several alternate embodiments, the resilient couplings 512, 904, and 1306, as described above with reference to Figs. 5B, 9B and 13B, are split into one or more pieces by splitting solder preform, conductive epoxy, non-conductive epoxy, or glass frit.

In several alternate embodiments, the bond pads 564, 926, and 1368 as described above with reference to Figs. 5B, 9B and 13B, are split into one or more pieces by splitting the bond pads 564, 926, and 1368 by any conventional splitting method.

In several alternate embodiments, the resilient couplings 512, 904, and 1306 as described above with reference to Figs. 5B, 9B and 13B, further electrically couple the respective sensors 504, 902, and 1304 to the housings 502, 602, 1302, and 1402, as described above with reference to Figs. 5B, 9B and 13B, and 14B.

In several alternate embodiments, the housings 502 ,602, 1302, and 1402, as described above with reference to Figs. 5A, 6A, 13A, and 14A, are any conventional substrate.

In several alternate embodiments, the sensor packages 405 size is reduced by vertically stacking the components of the sensor packages 405.

In several alternate embodiments, the sensor packages 405 performance is improved by reducing the communication path length between the controller assembly 508 and the sensors 504, 902, and 1304, as substantially described above with reference to Figs. 5A through 27B. The performance improvement may be, for example, reduced parasitic capacitance, resistance, or inductance.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. A sensor apparatus comprising;
a housing including a cavity;
a first end cap on one end of the housing;
a second end cap on an opposite end of the housing;
a sensor module coupled to the first end cap and supported within the housing cavity, including a plurality of sensor packages, each sensor package having an axis of sensitivity positioned in a different spatial direction;
a plurality of first sealing members for sealing the interface between the first end cap and the housing;
a plurality of second sealing members for sealing the interface between the second end cap and the housing;
a plurality of first coupling members for coupling the first end cap to the housing; and
a plurality of second coupling members for coupling the second end cap to the housing.

2. A sensor package comprising;
a package; and
a sensor coupled to the package.

3. A sensor assembly package, comprising;
a plurality of sensor packages, each sensor package having an axis of sensitivity; and
wherein each sensor package is positioned with its axis of sensitivity in a different spatial direction.

4. A method of coupling a controller onto a package, comprising; dispensing an adhesive on the package;
placing the controller onto the adhesive;

curing the adhesive;

wire-bonding the controller to the package; and

encapsulating the controller and the wire bonds.

5. A method of assembling a sensor package including a package and a sensor, comprising coupling the sensor to the package.

6. A method of assembling a multi-axis sensor assembly, comprising:

a plurality of sensor packages, each sensor package having an axis of sensitivity; and

positioning each sensor package with its axis of sensitivity in a different spatial direction.

7. A sensor module package comprising;

one or more substrates including one or more slots; and

one or more sensors positioned within the slots.

8. A method of assembling a sensor package comprising one or more substrates and one or more sensors, comprising coupling the sensor to the substrates.

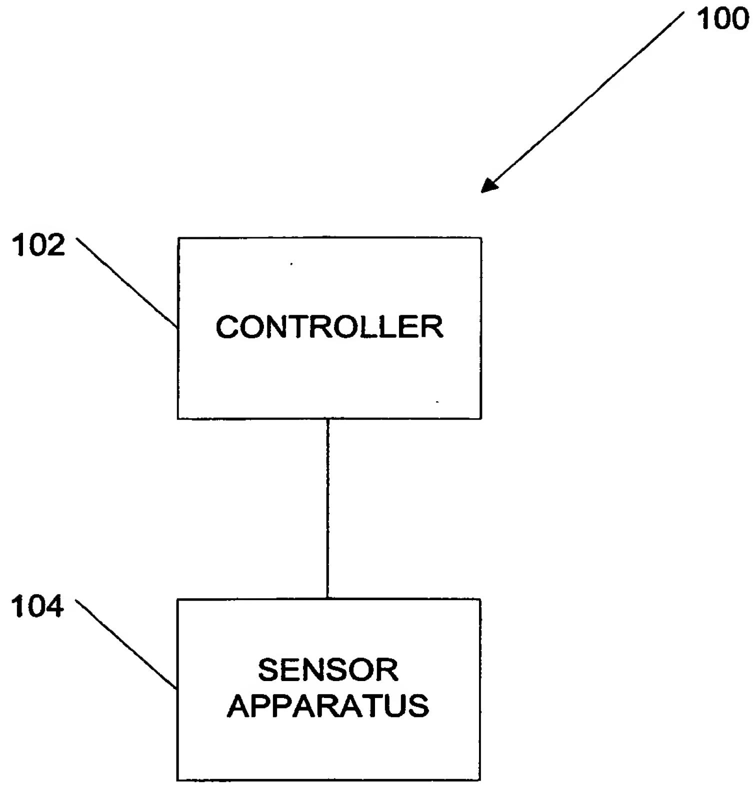


FIGURE 1

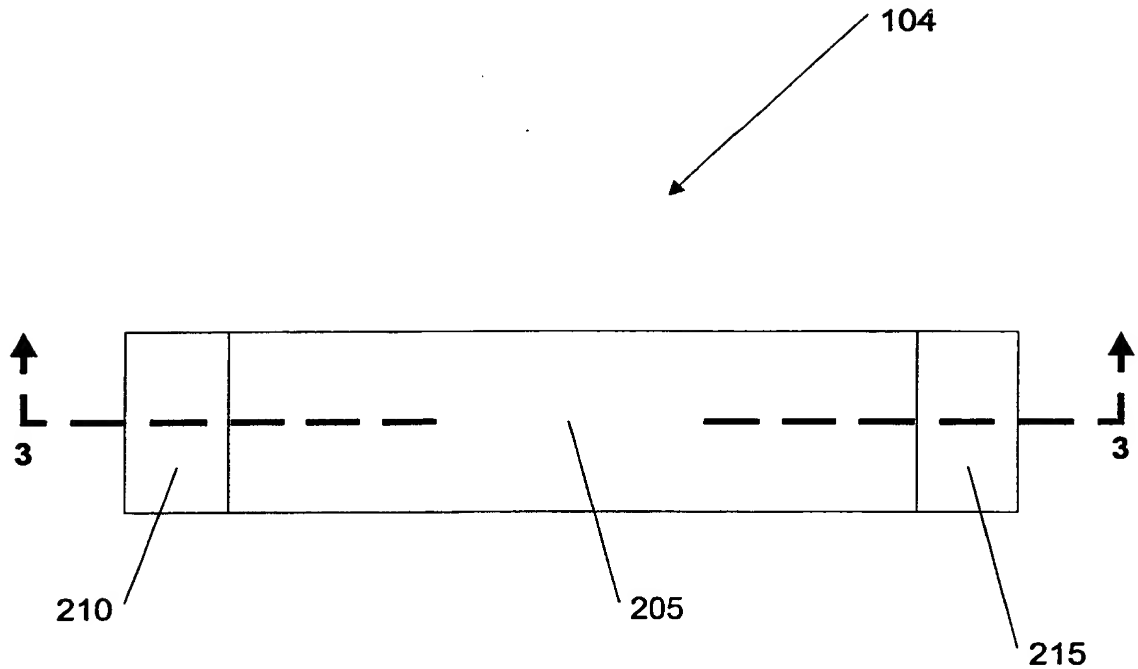
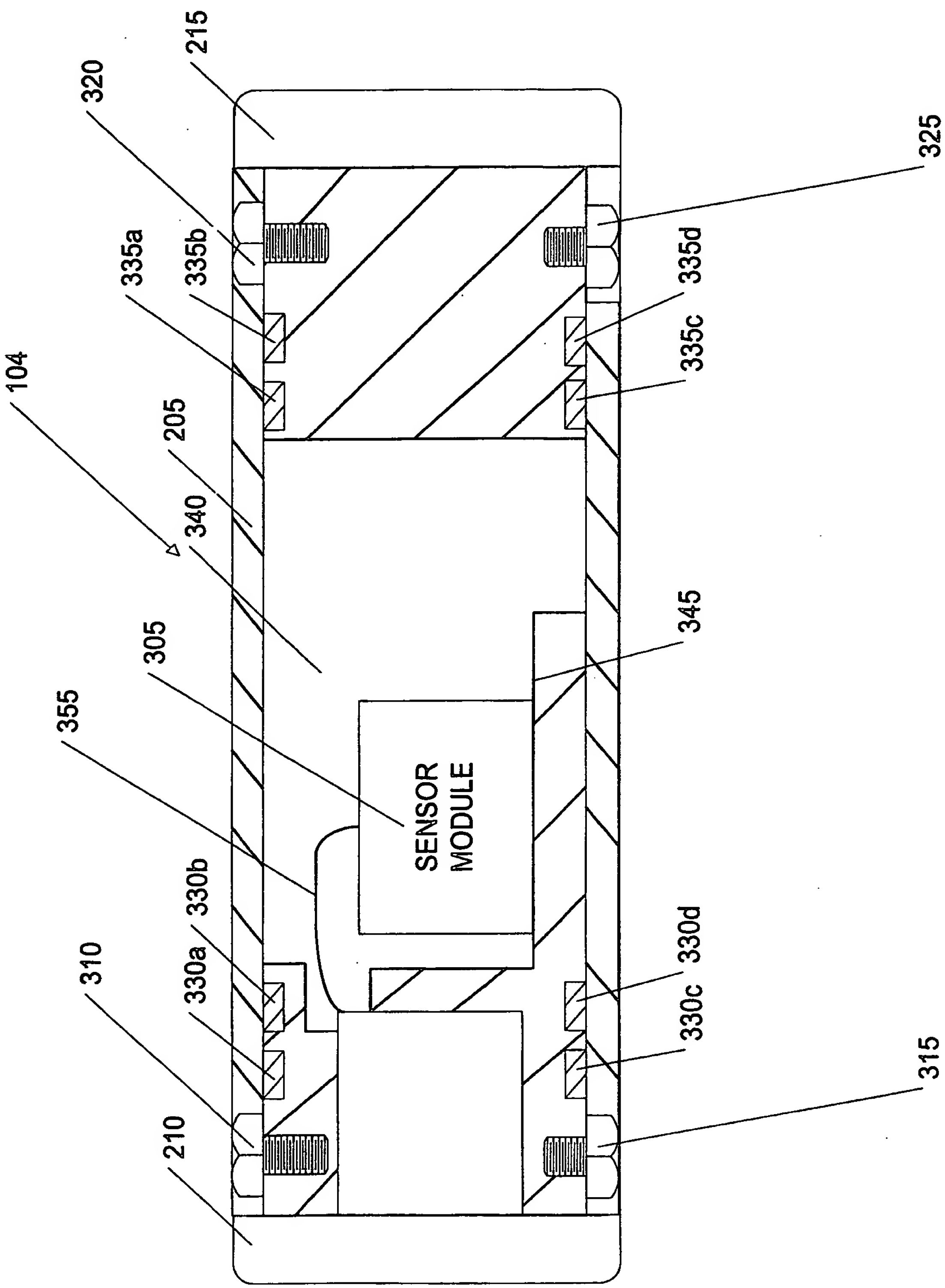


FIGURE 2


215
320
325
335a
335b
335d
335c
104
205
340
345
305
SENSOR
MODULE
355
330b
330d
310
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330c
315
210

FIGURE 3

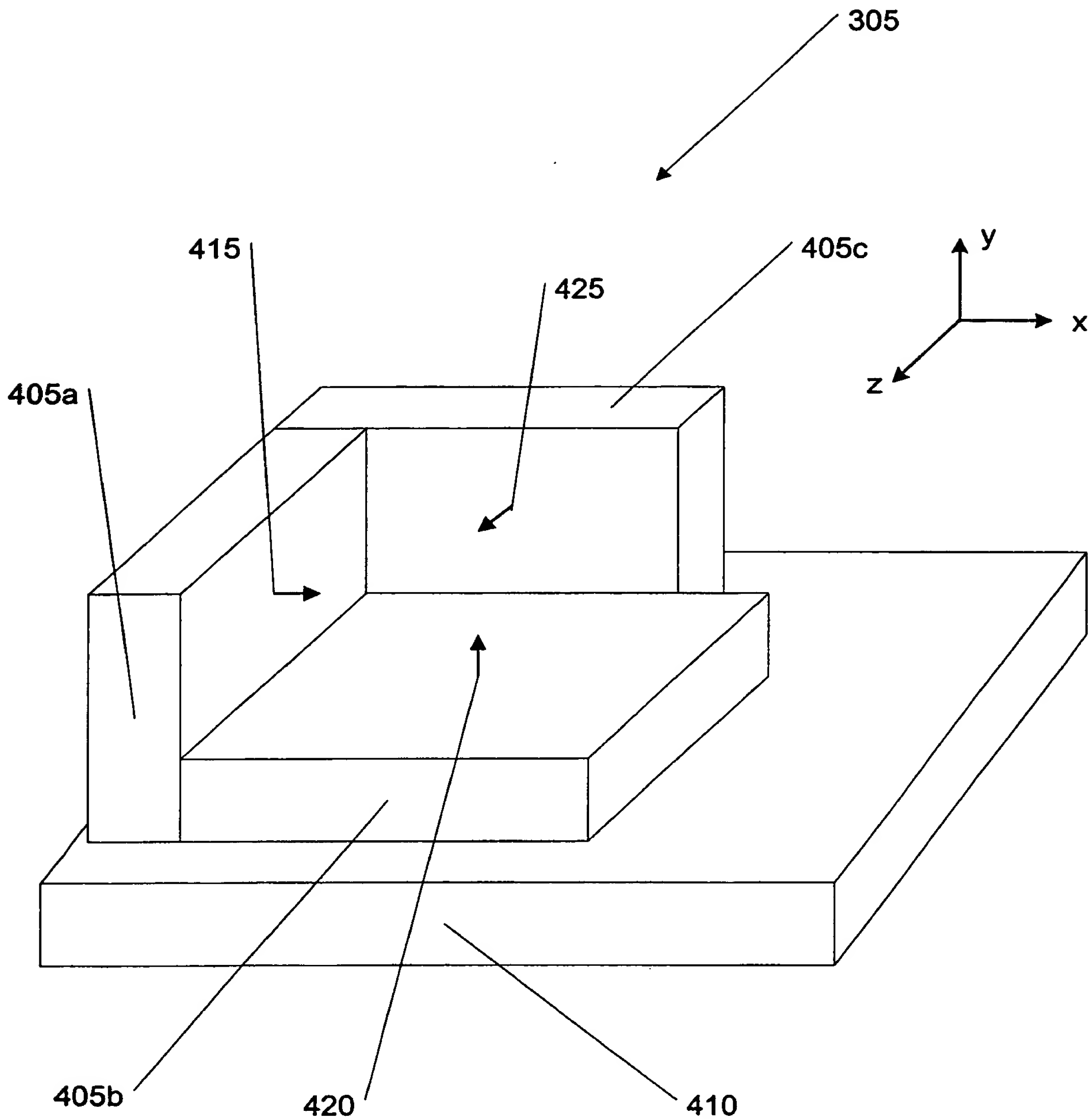


FIGURE 4

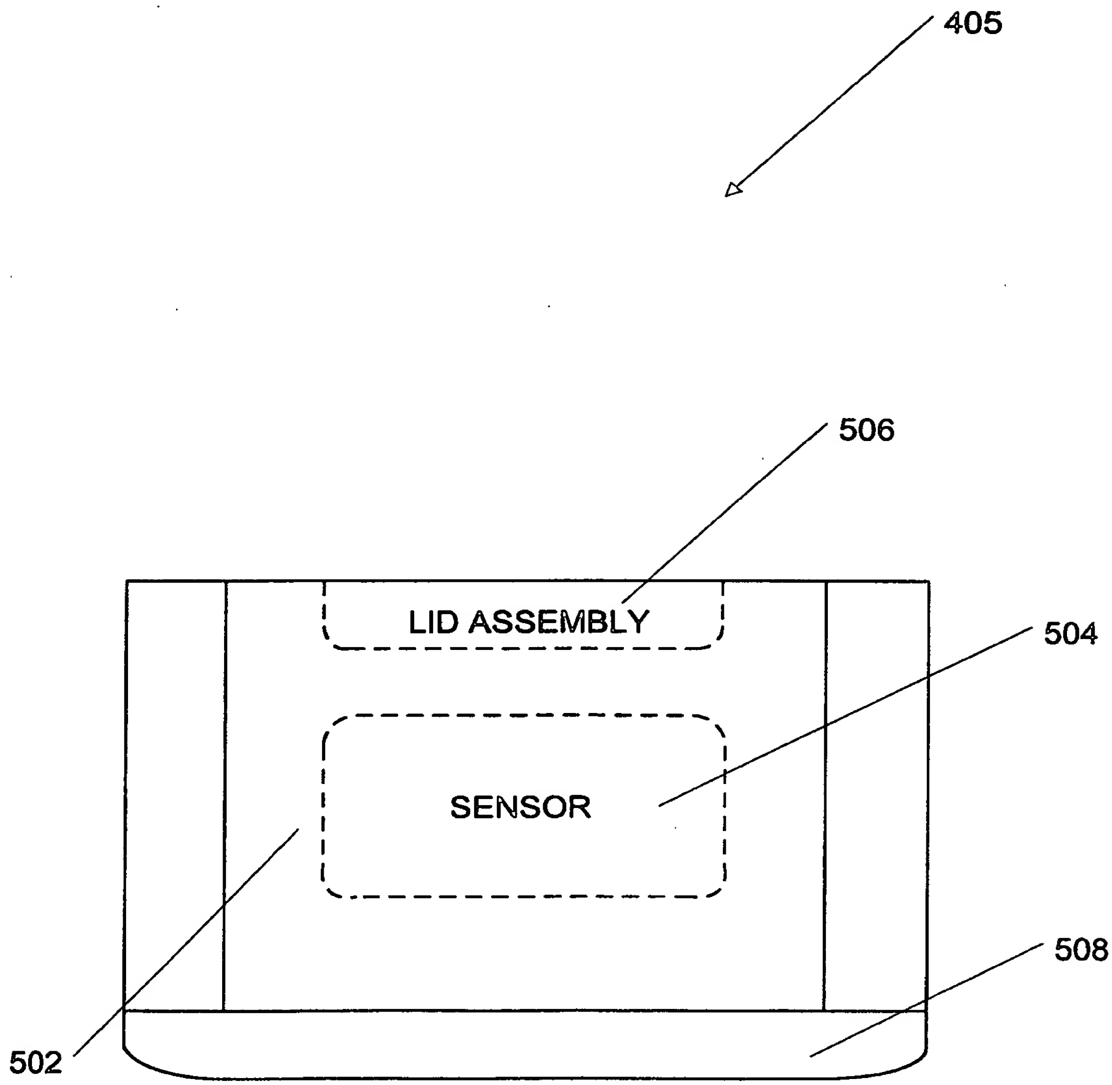
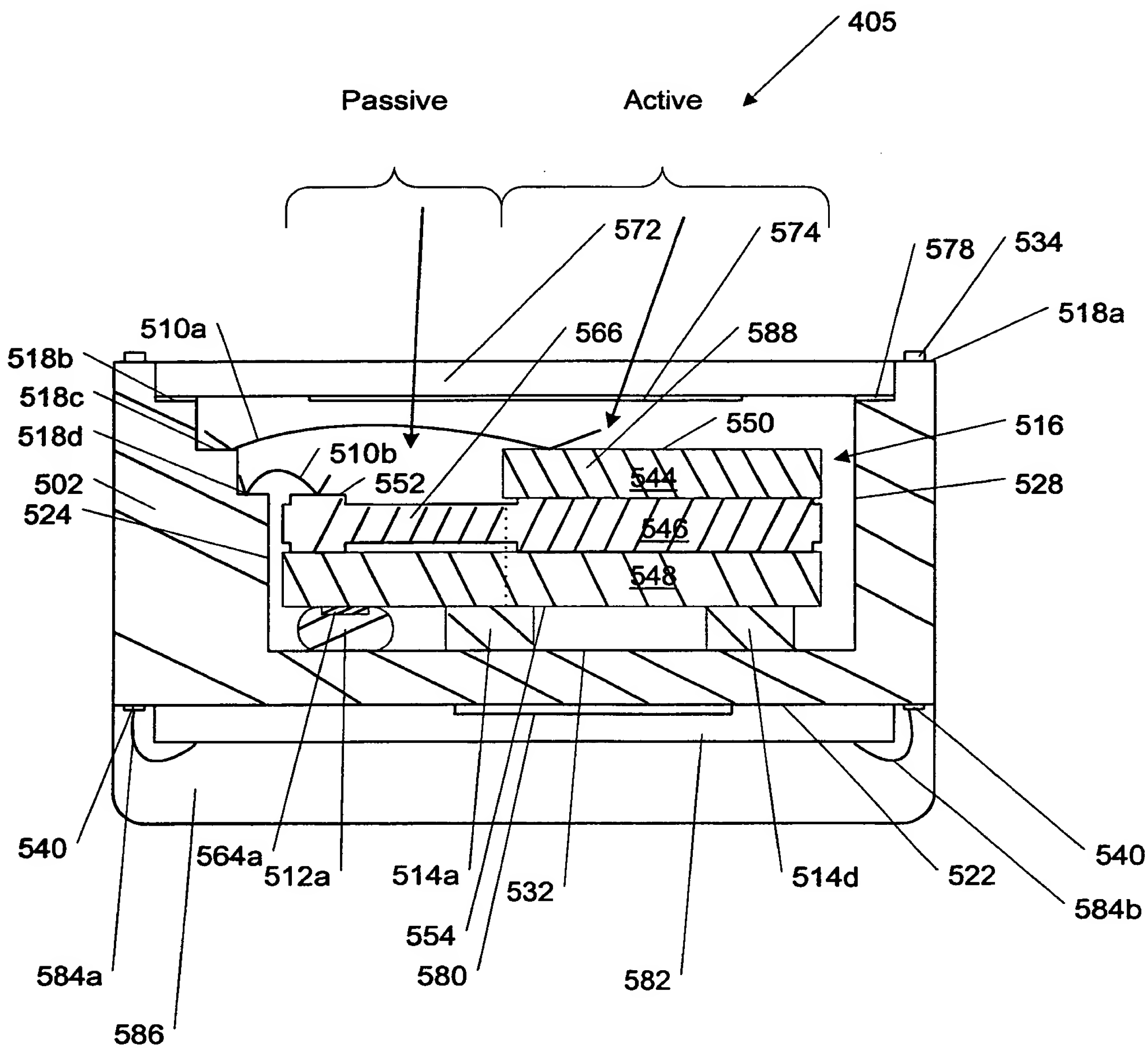


FIGURE 5A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Passive
Active
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574
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518a
510a
566
588
518b
518c
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502
524
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510b
552
544
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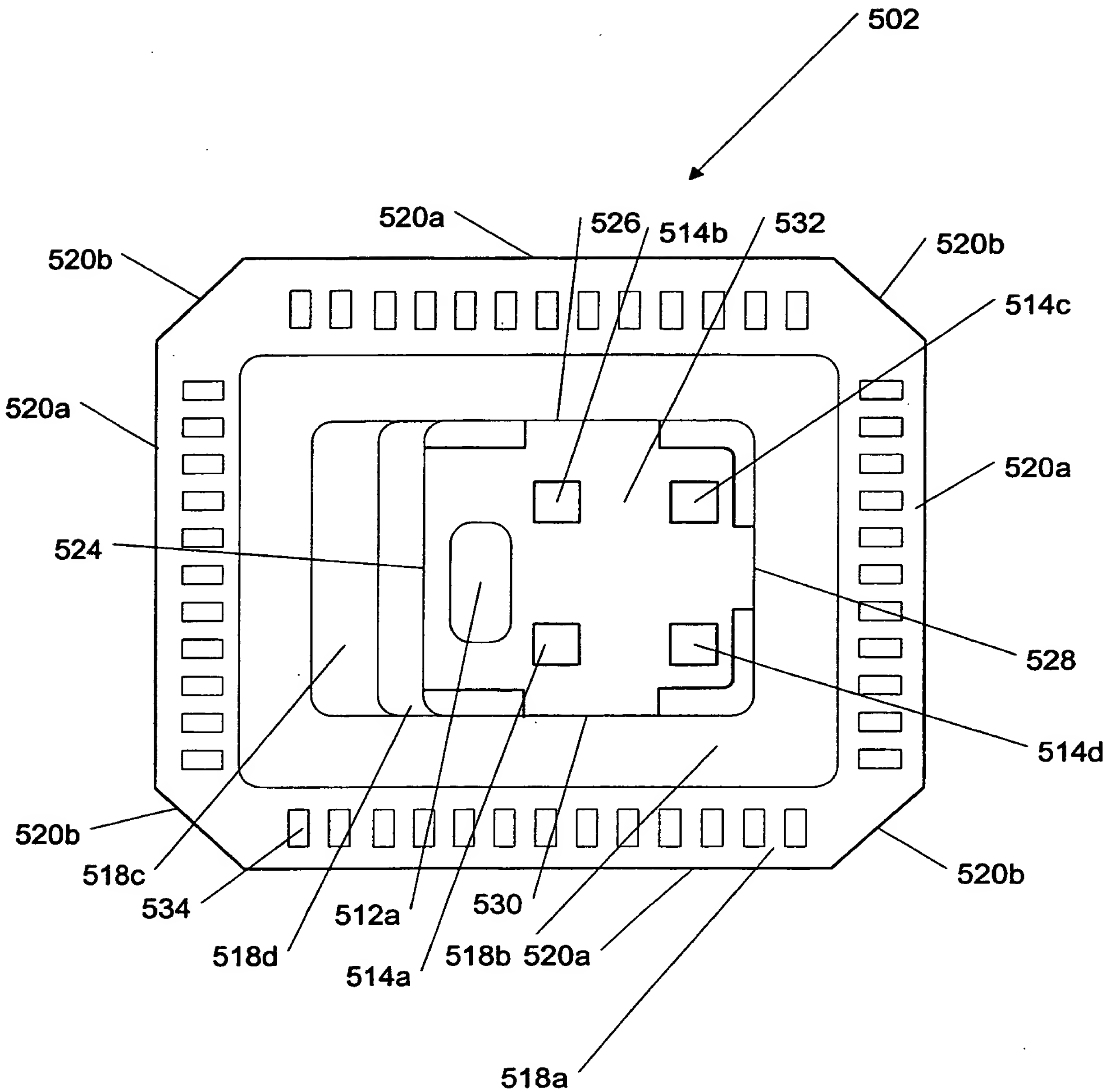
582
586

FIGURE 5B


502
520a
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518a

FIGURE 5C

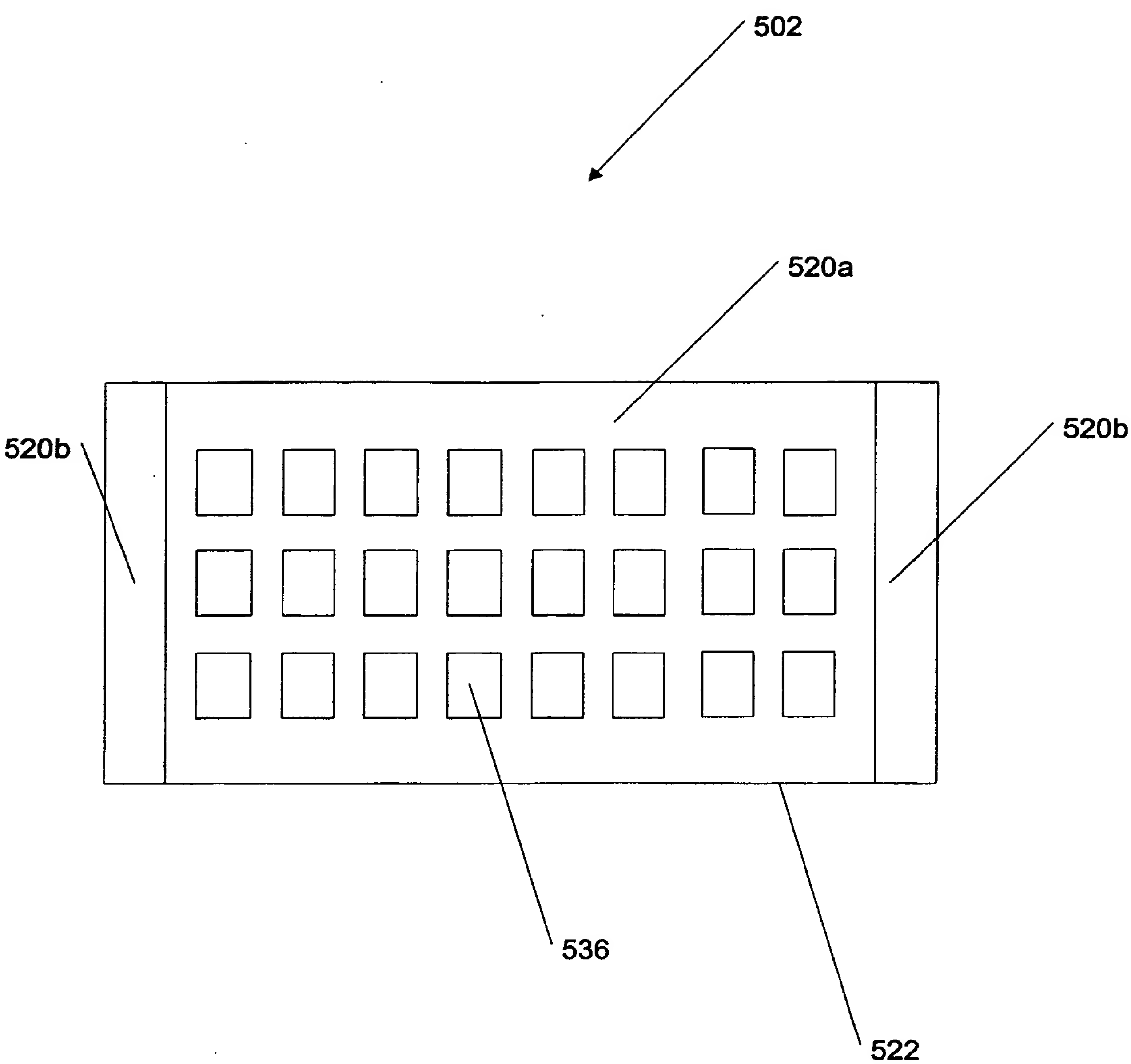


FIGURE 5D

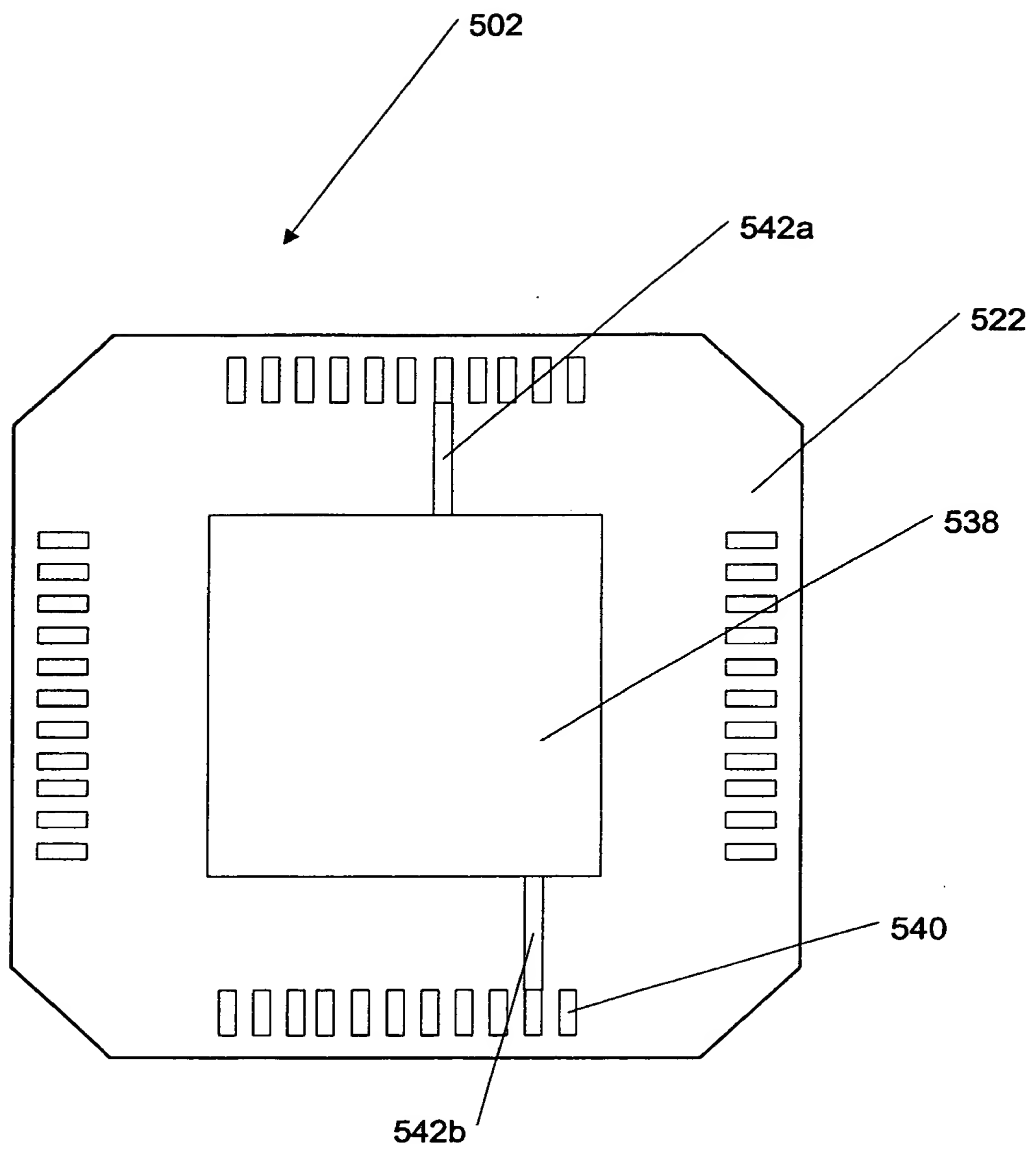


FIGURE 5E

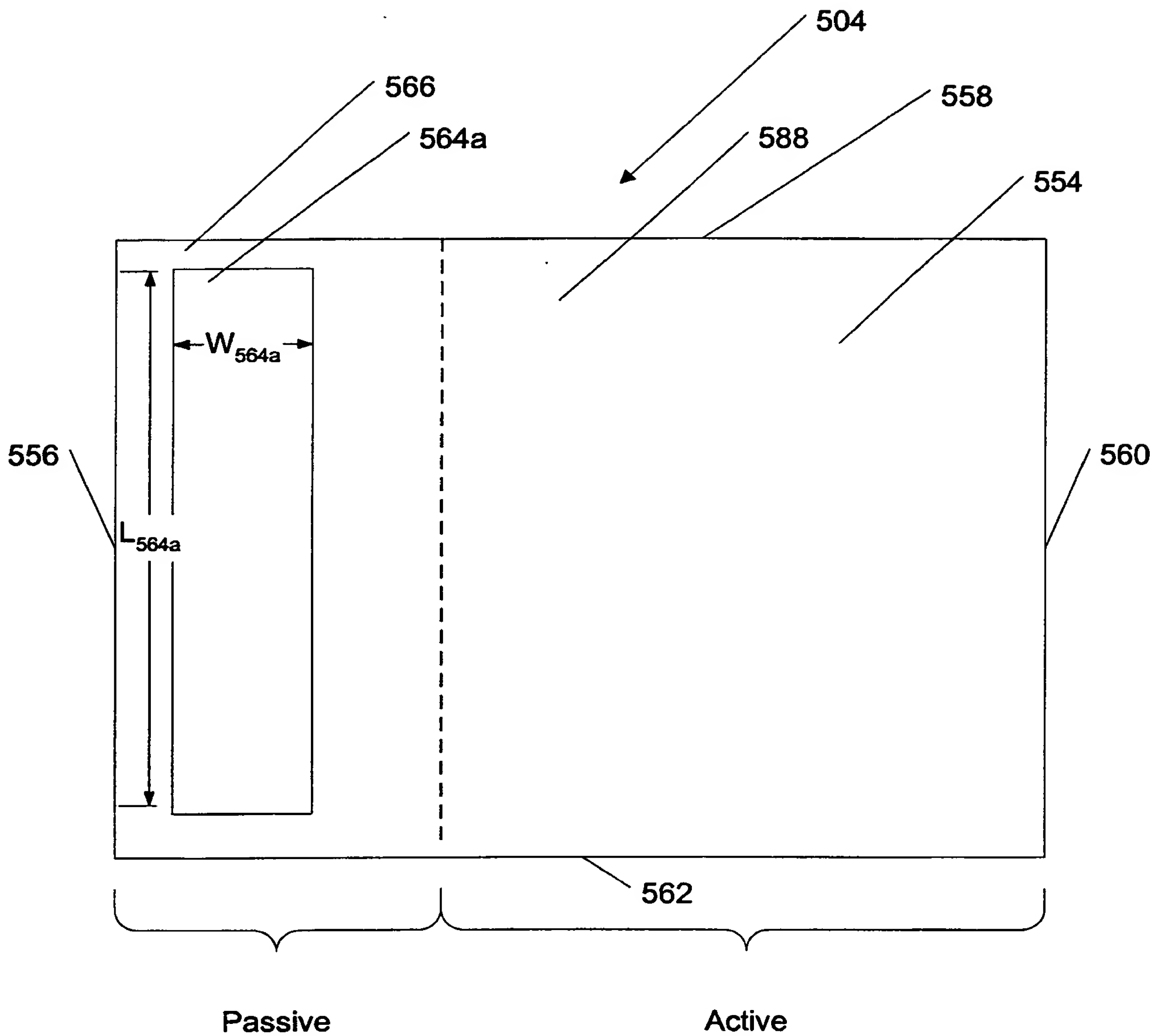

504
566
564a
588
558
554
W_{564a}
556
L_{564a}
560
562
Passive
Active

FIGURE 5F

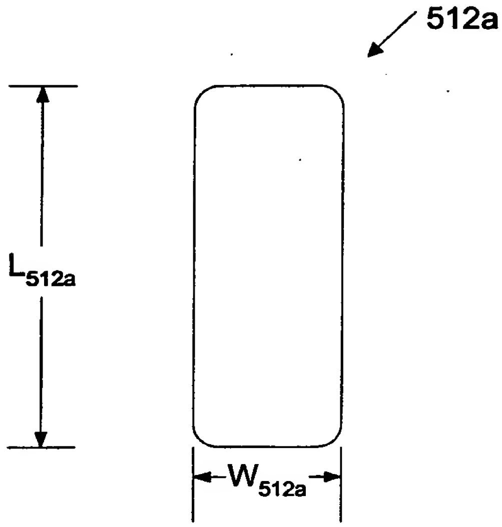


FIGURE 5G

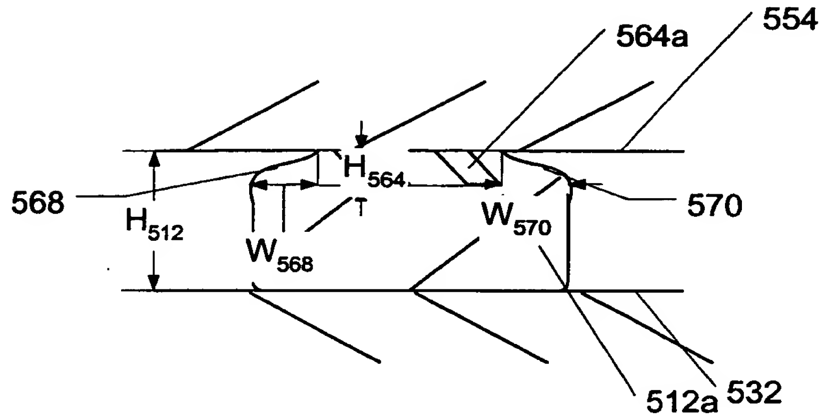


FIGURE 5H

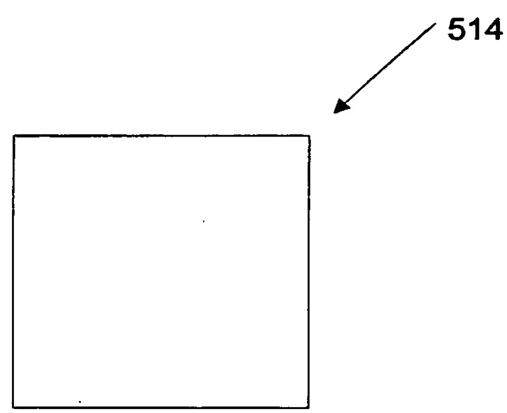


FIGURE 5I

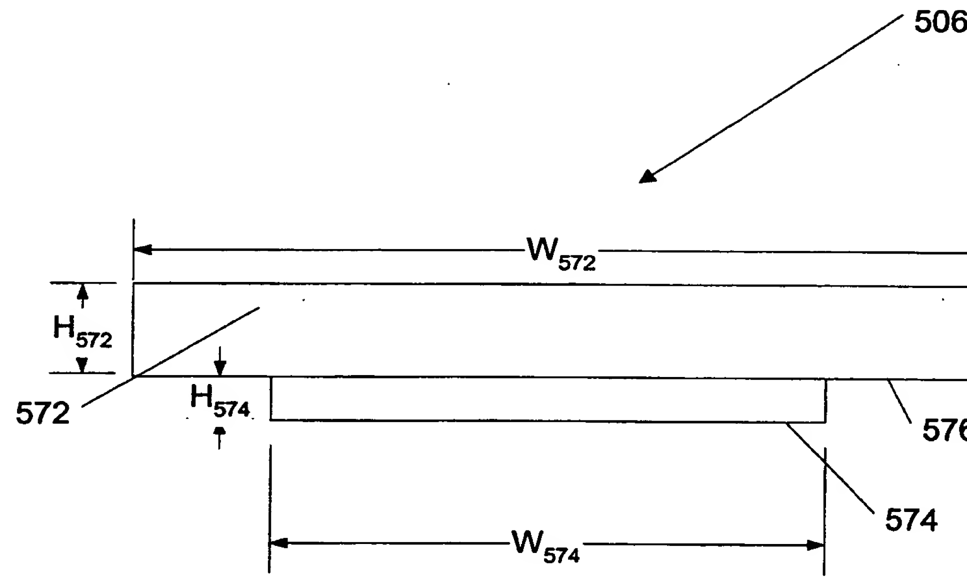


FIGURE 5J

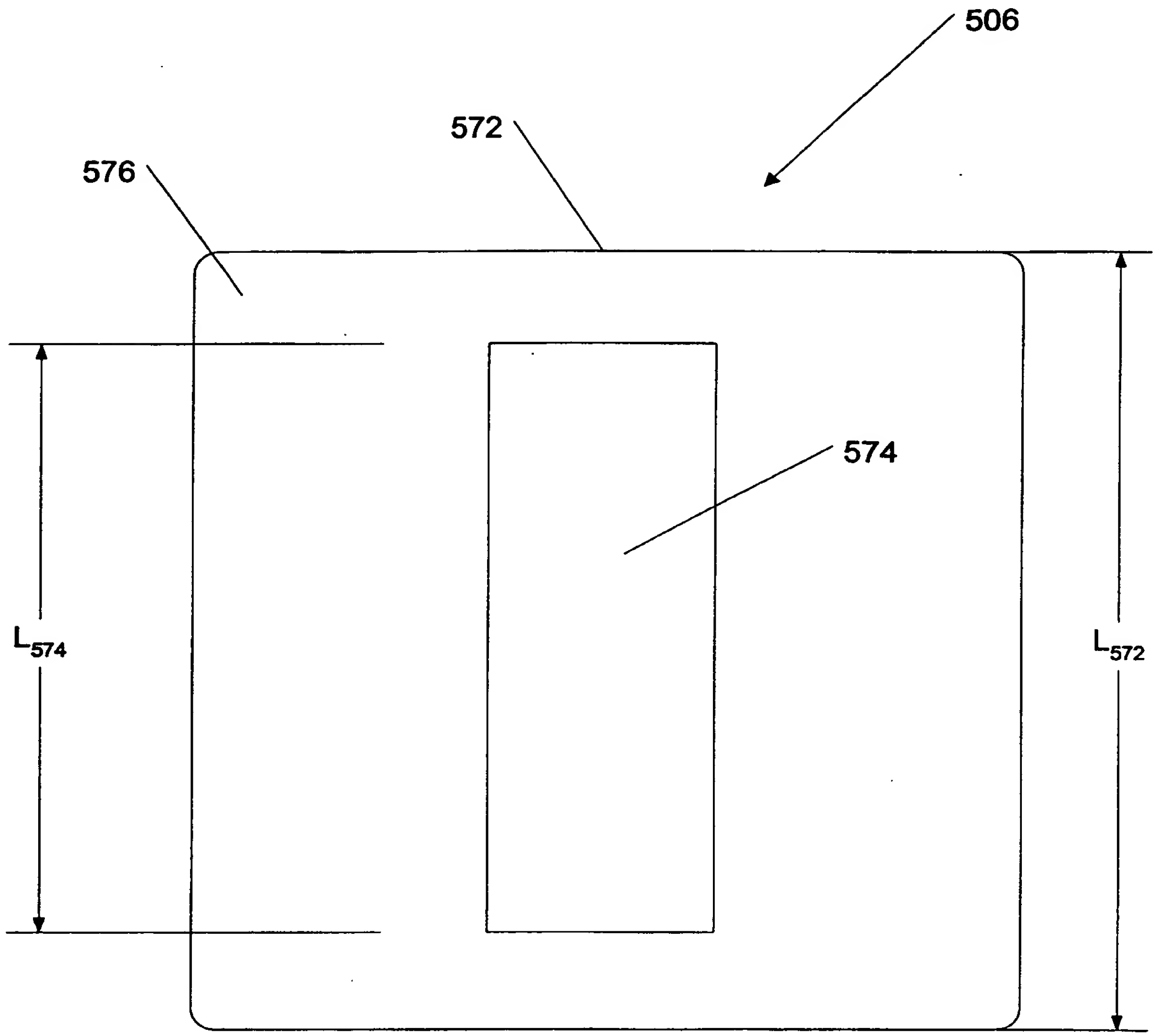


FIGURE 5K

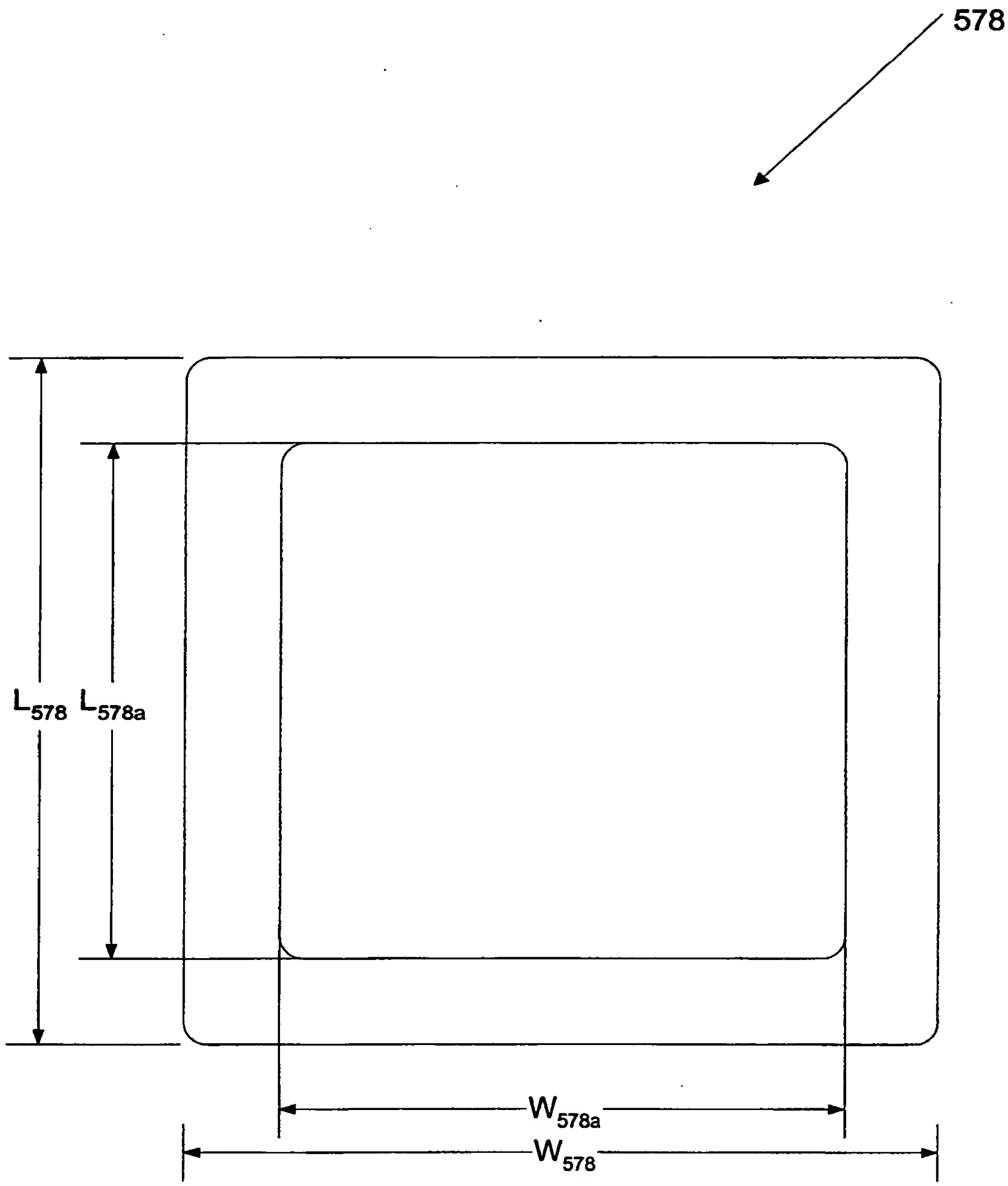


FIGURE 5L

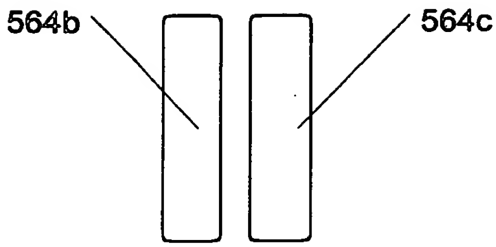


FIGURE 5M

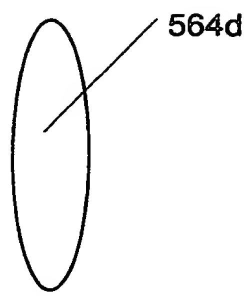


FIGURE 5N

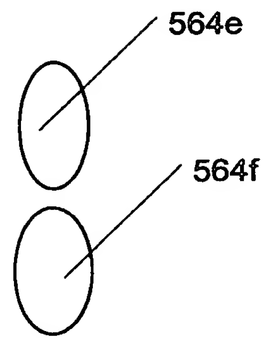


FIGURE 5O

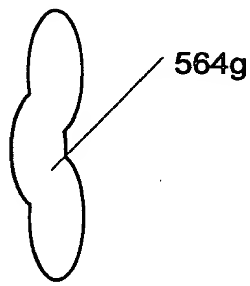


FIGURE 5P

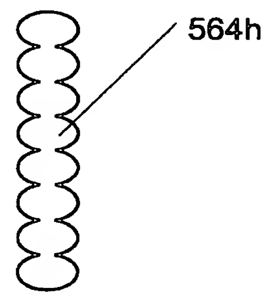


FIGURE 5Q

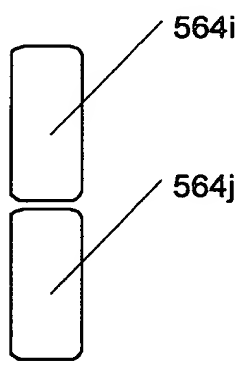


FIGURE 5R

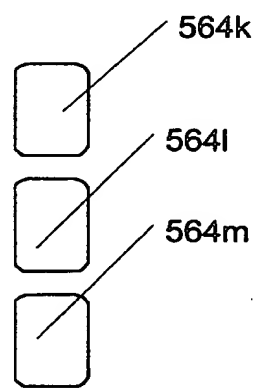


FIGURE 5S

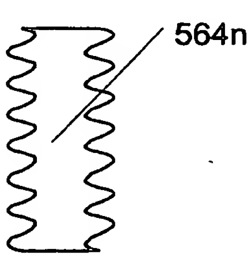


FIGURE 5T

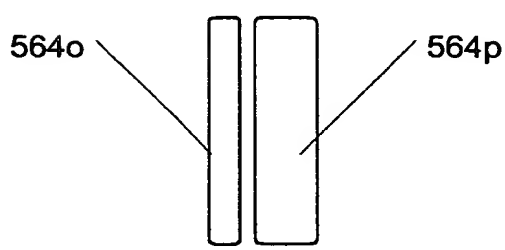


FIGURE 5U

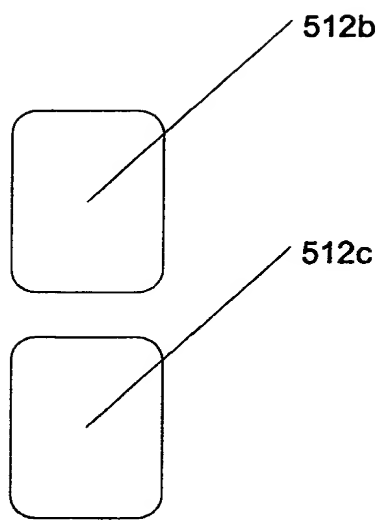


FIGURE 5V

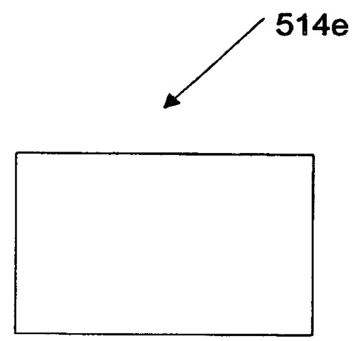


FIGURE 5W

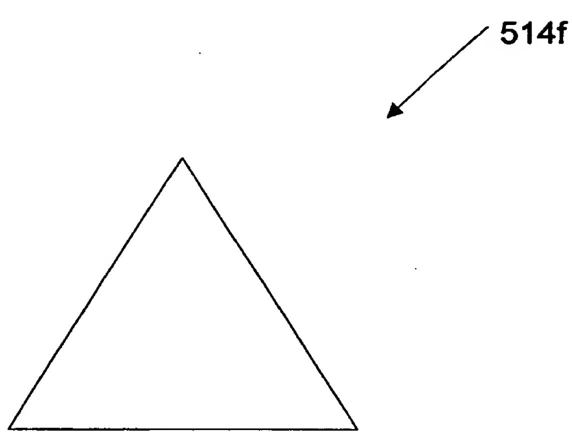


FIGURE 5X

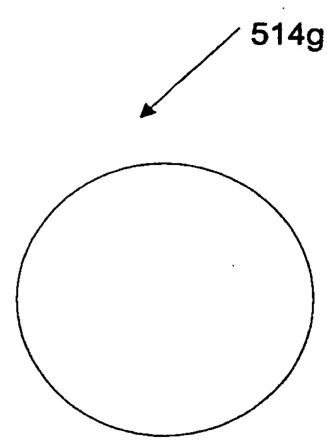


FIGURE 5Y

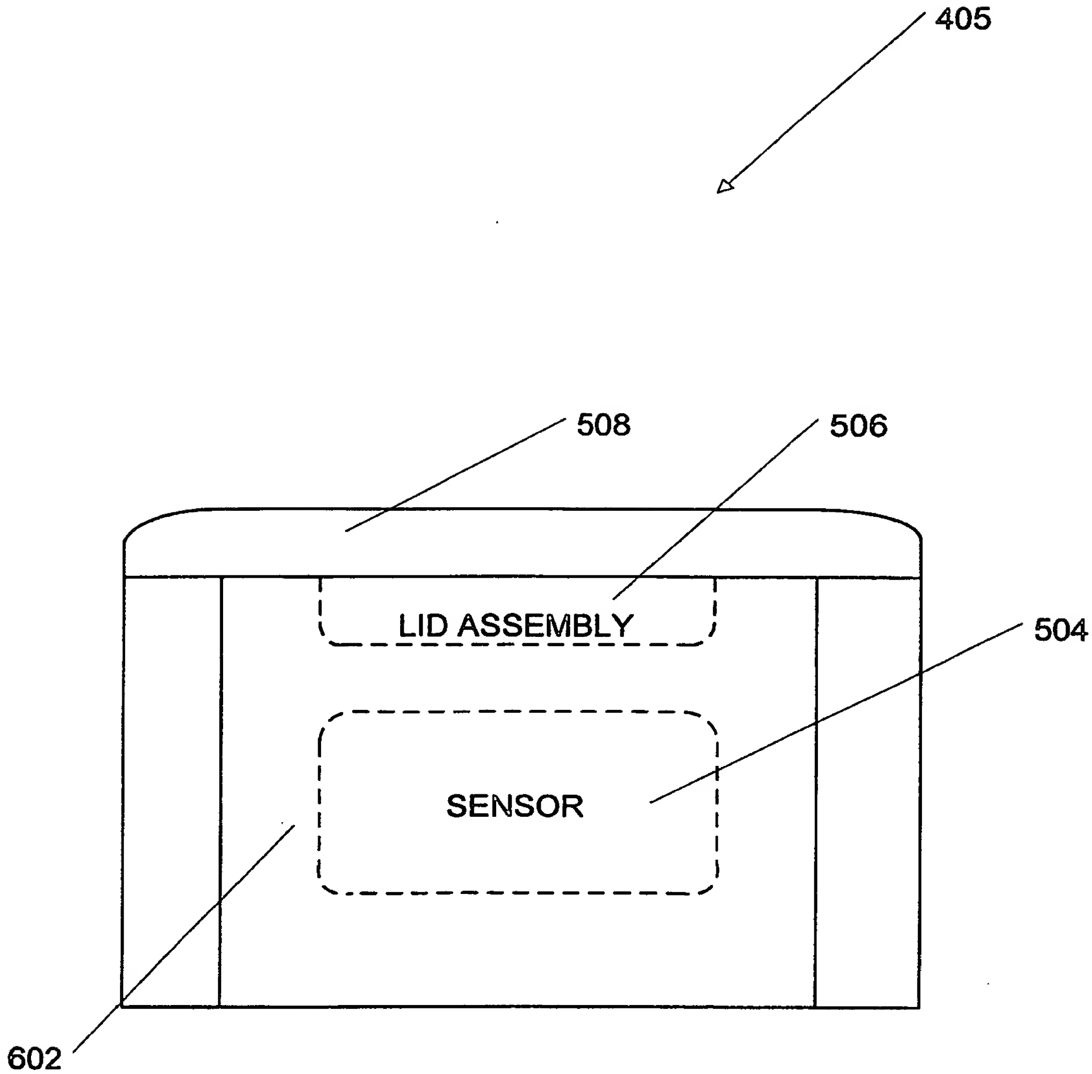
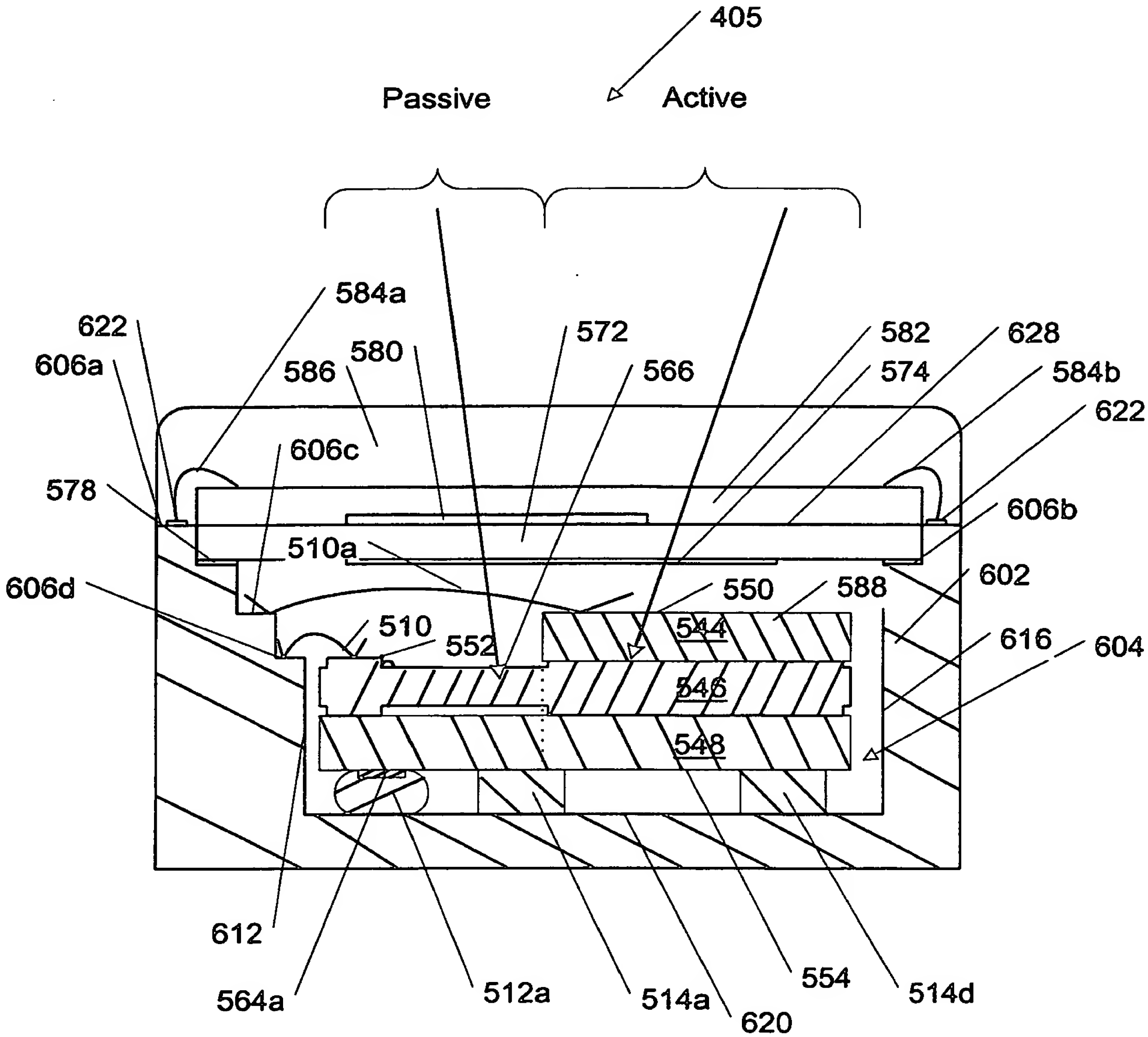


FIGURE 6A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Passive
Active
584a
622
572
582
628
580
606a
586
566
574
584b
622
606c
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606b
510a
602
606d
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544
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552
546
548
612
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512a
514a
620
554
514d

FIGURE 6B

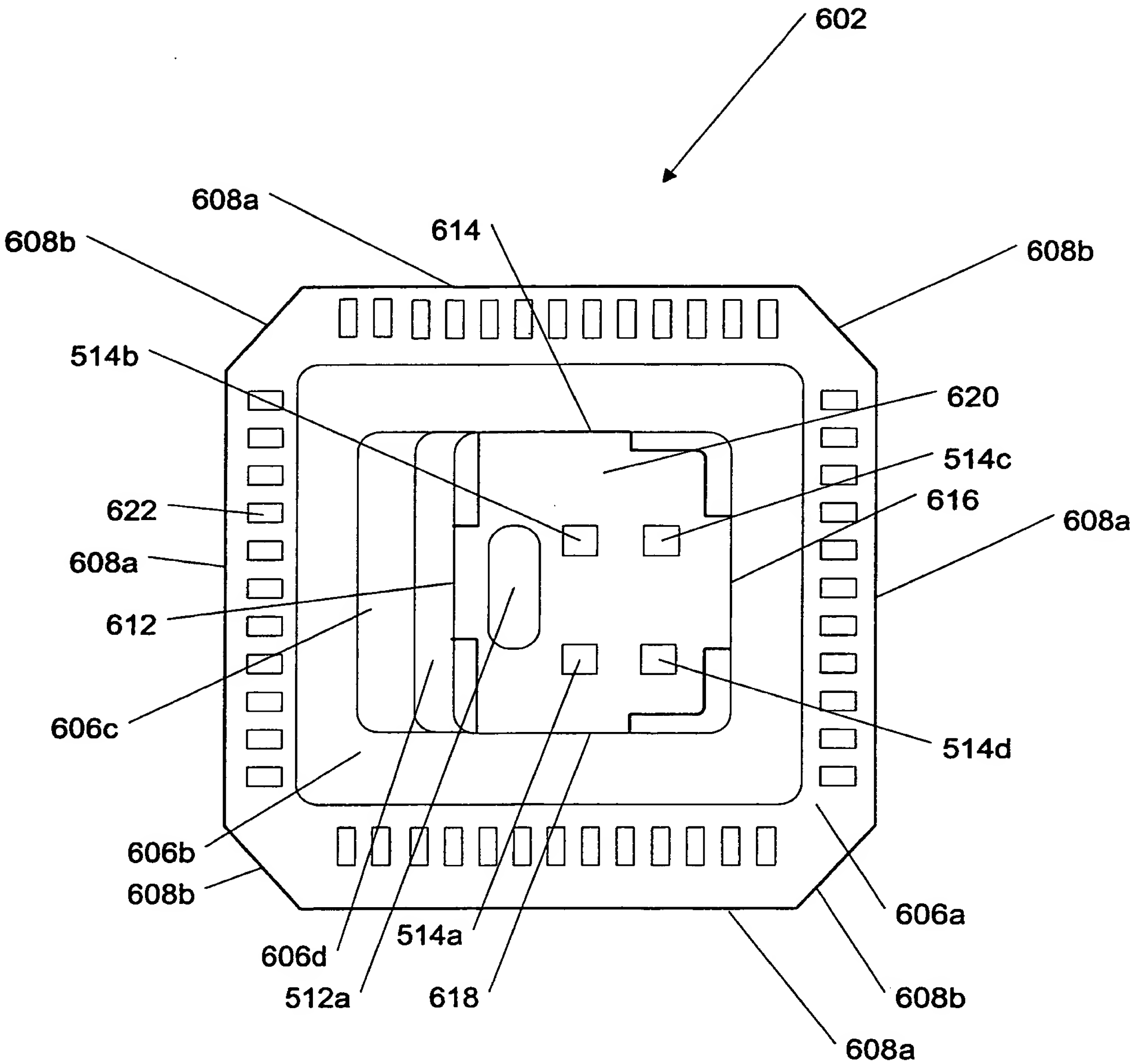
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FIGURE 6C

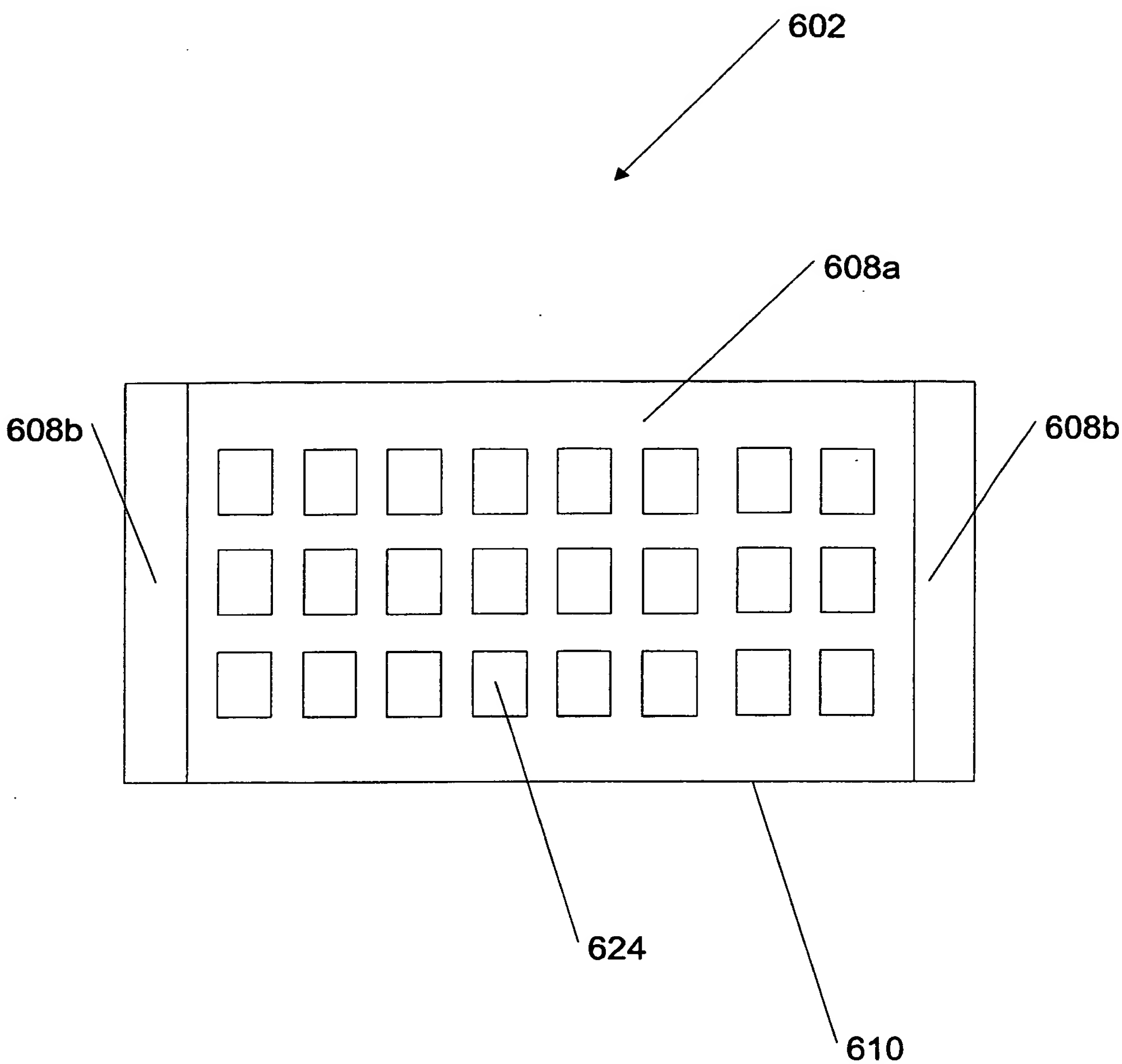


FIGURE 6D

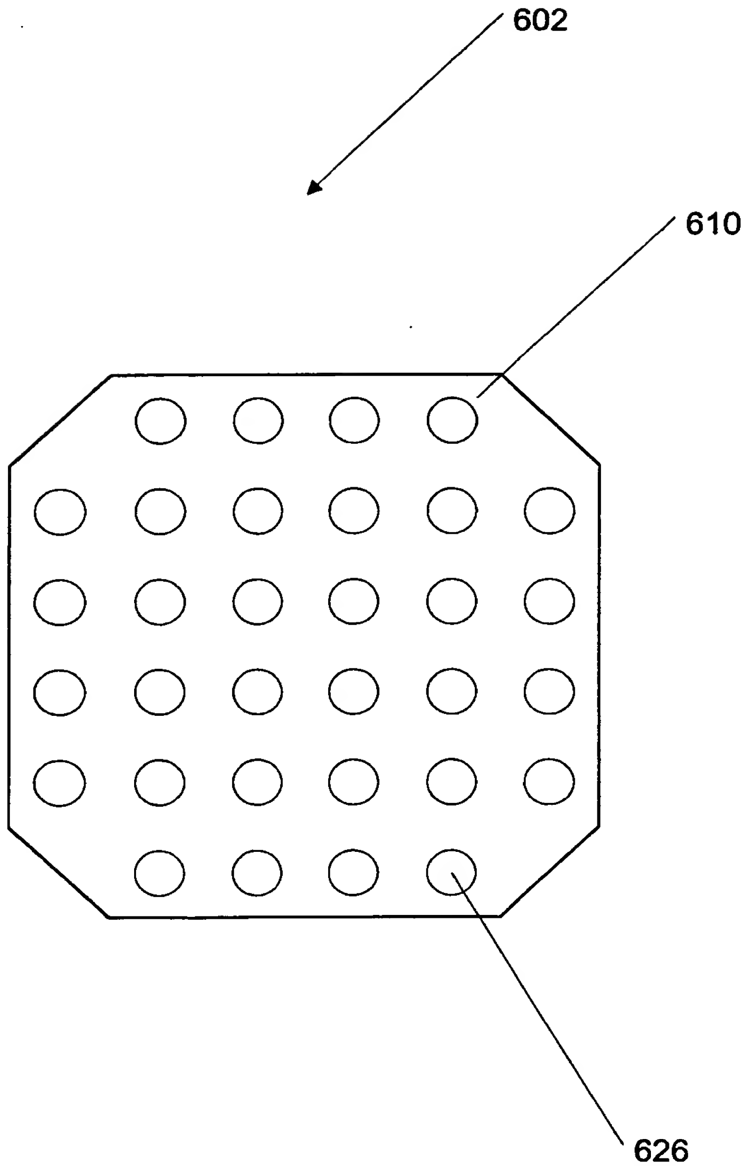
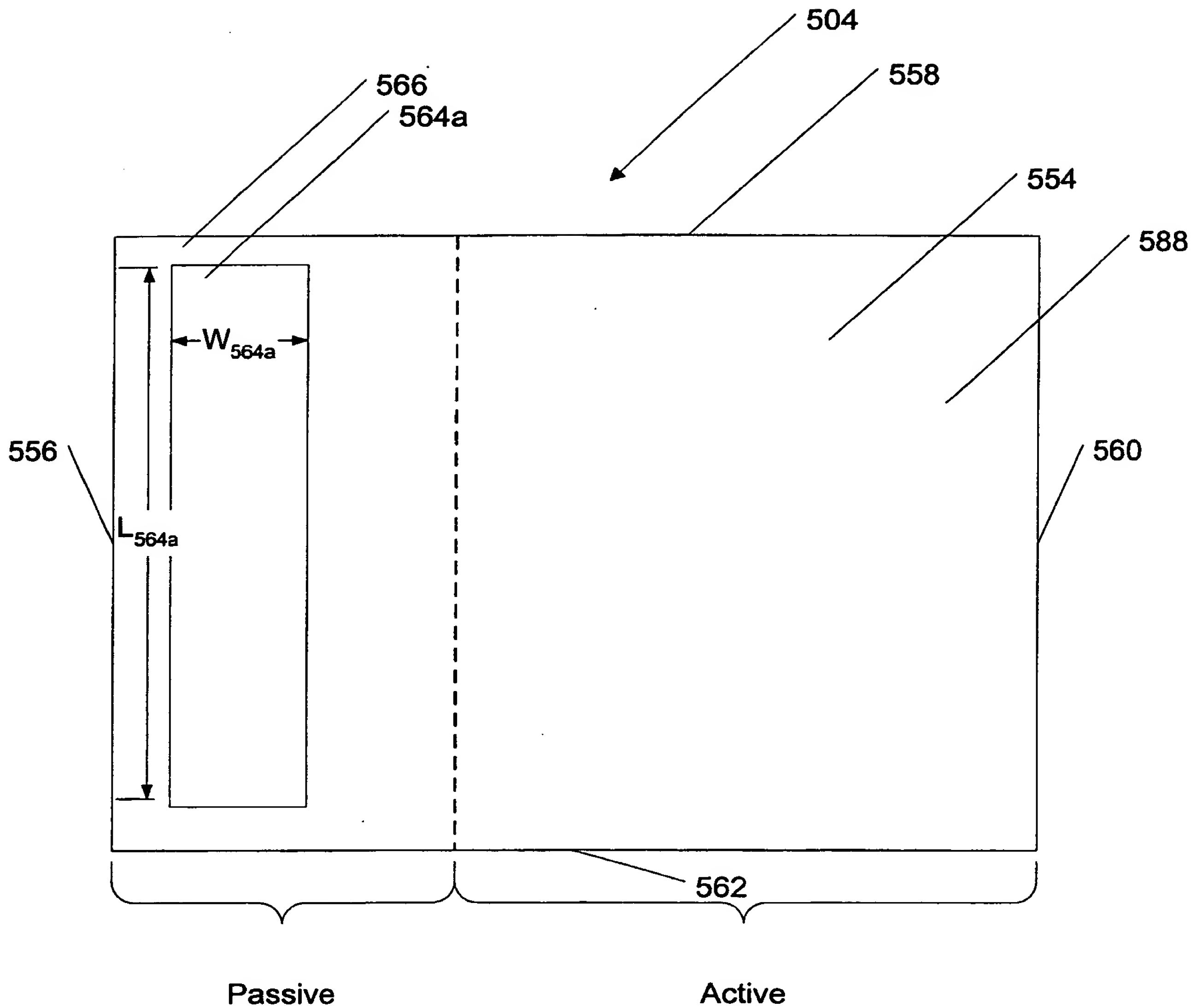


FIGURE 6E



504
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564a
558
554
588
W_{564a}
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L_{564a}
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562
Passive
Active

FIGURE 6F

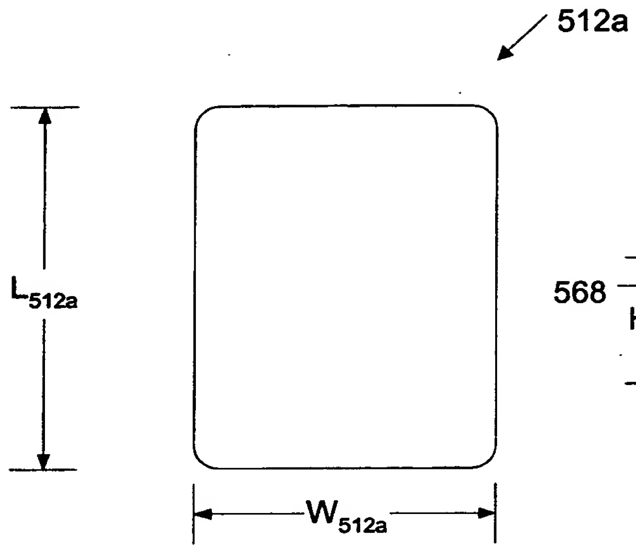


FIGURE 6G

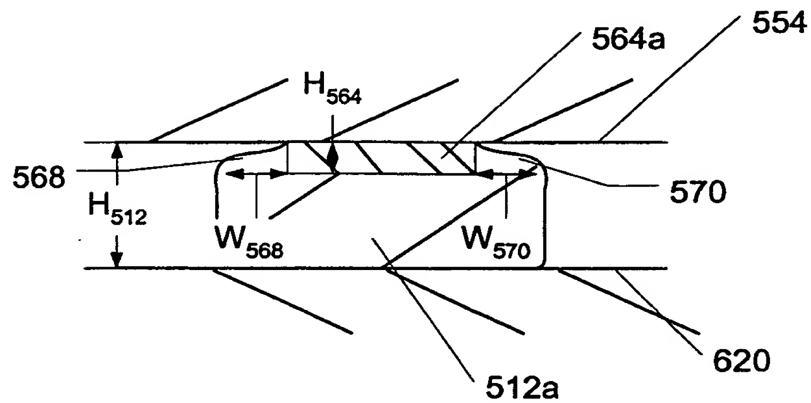


FIGURE 6H

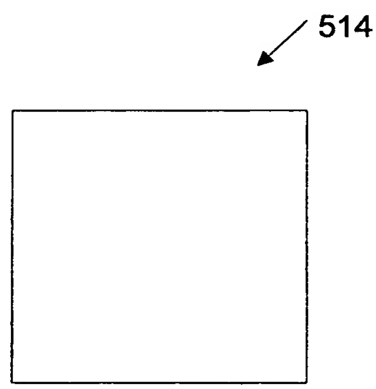


FIGURE 6I

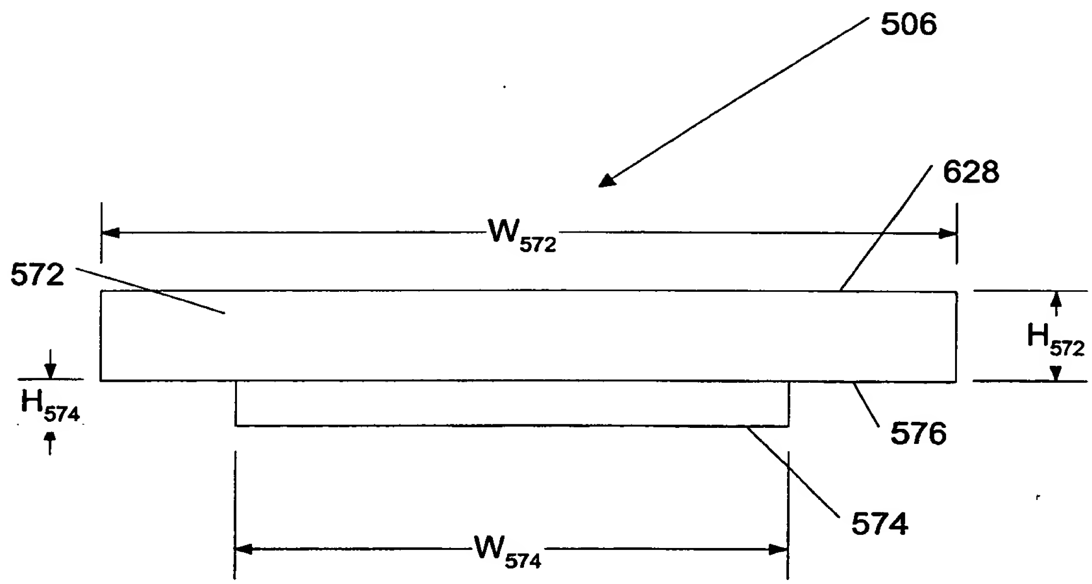


FIGURE 6J

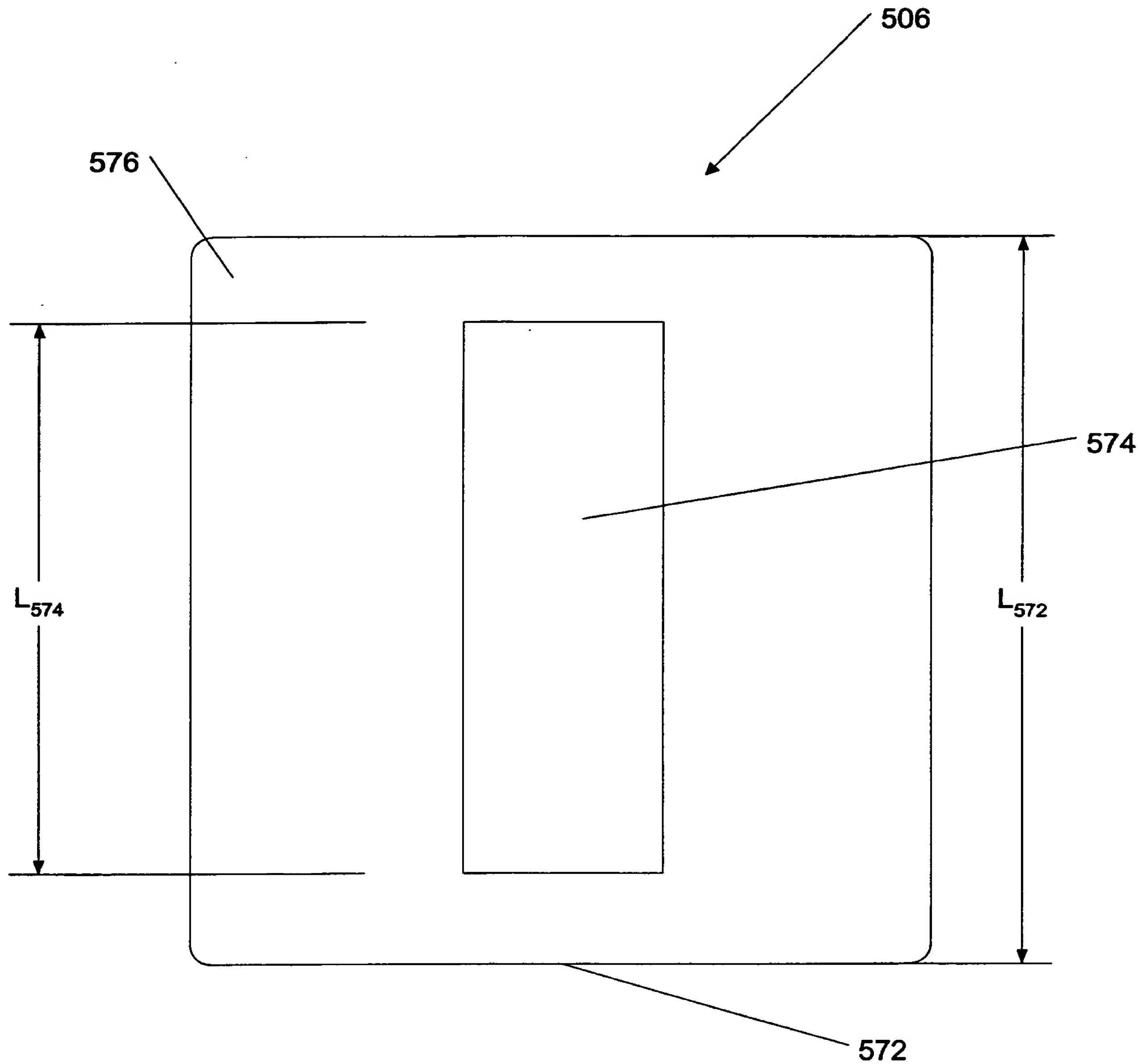


FIGURE 6K

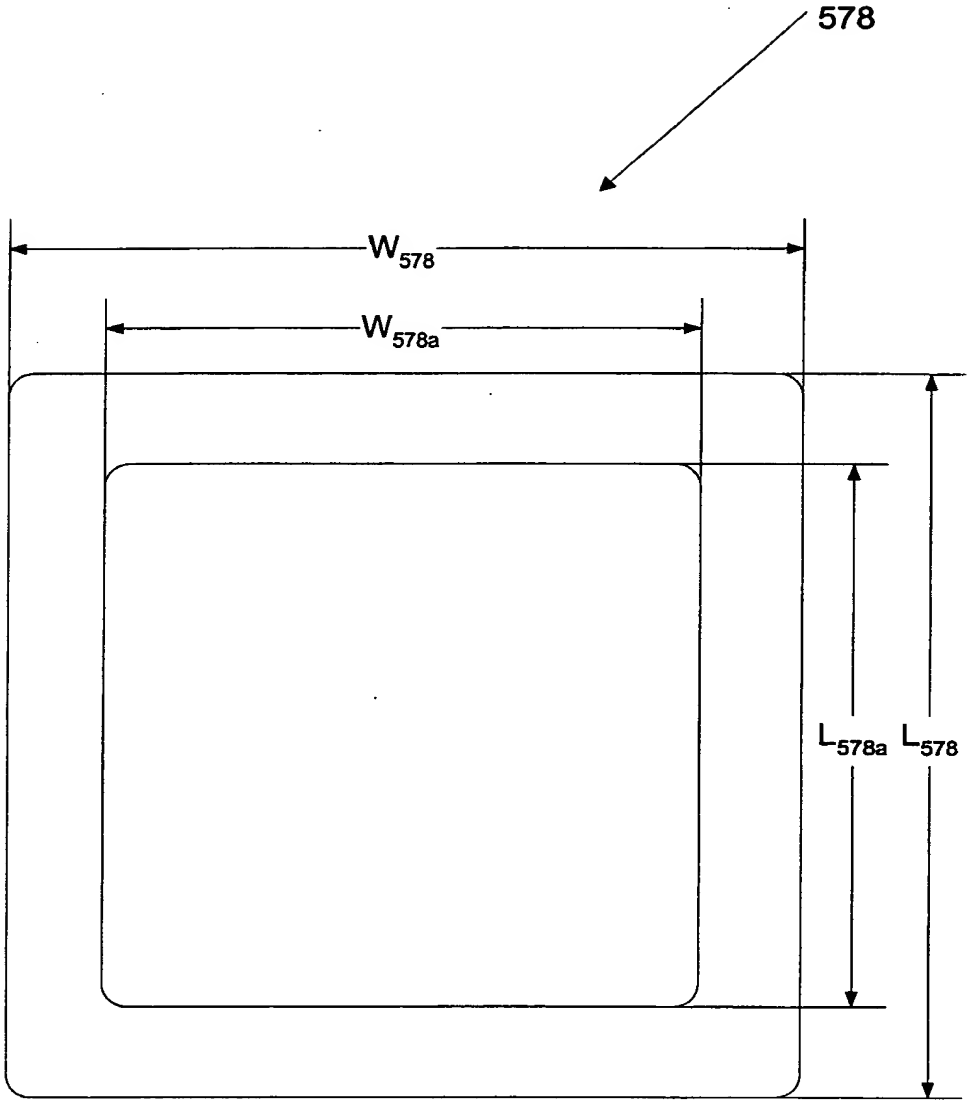


FIGURE 6L

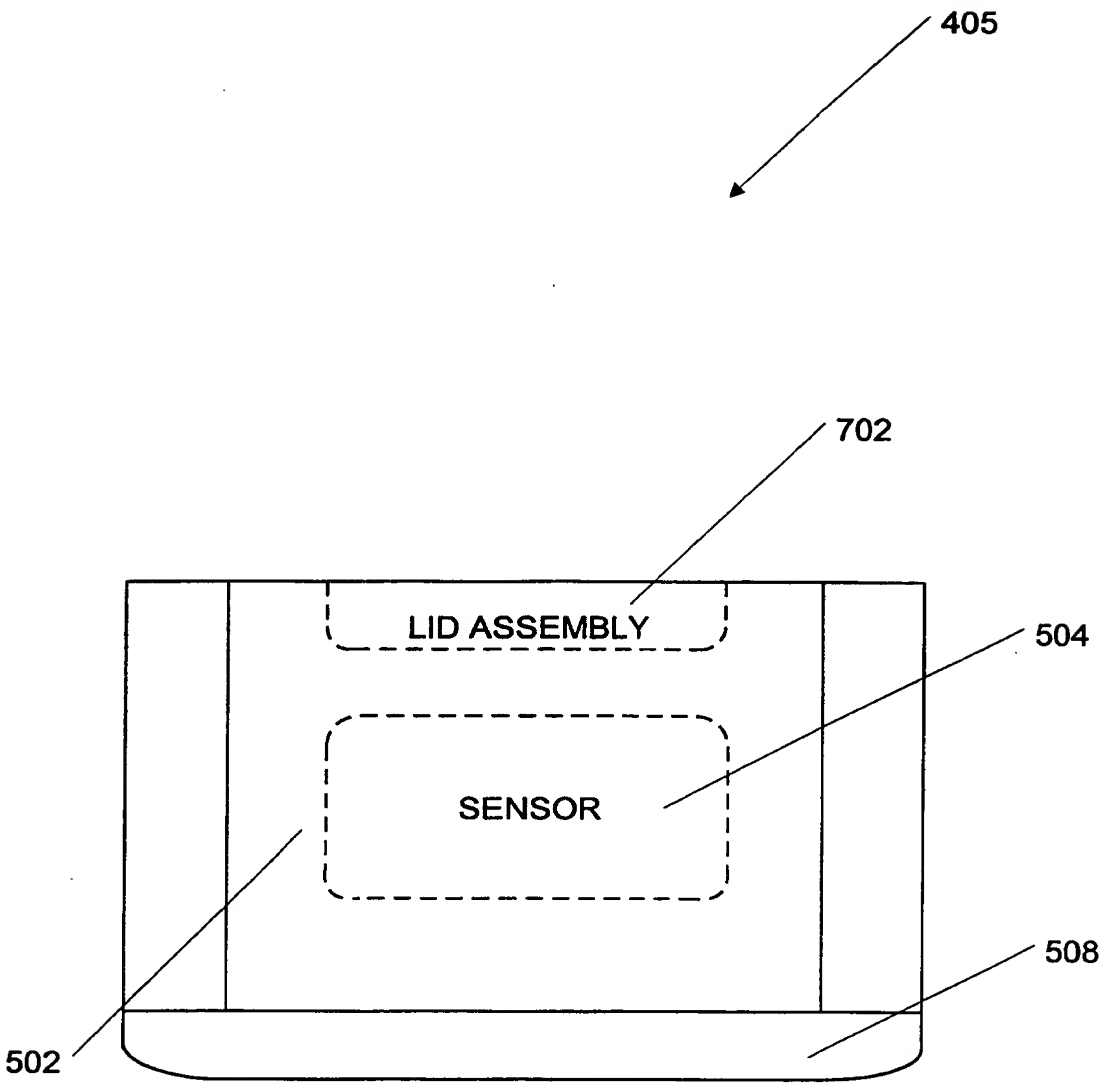
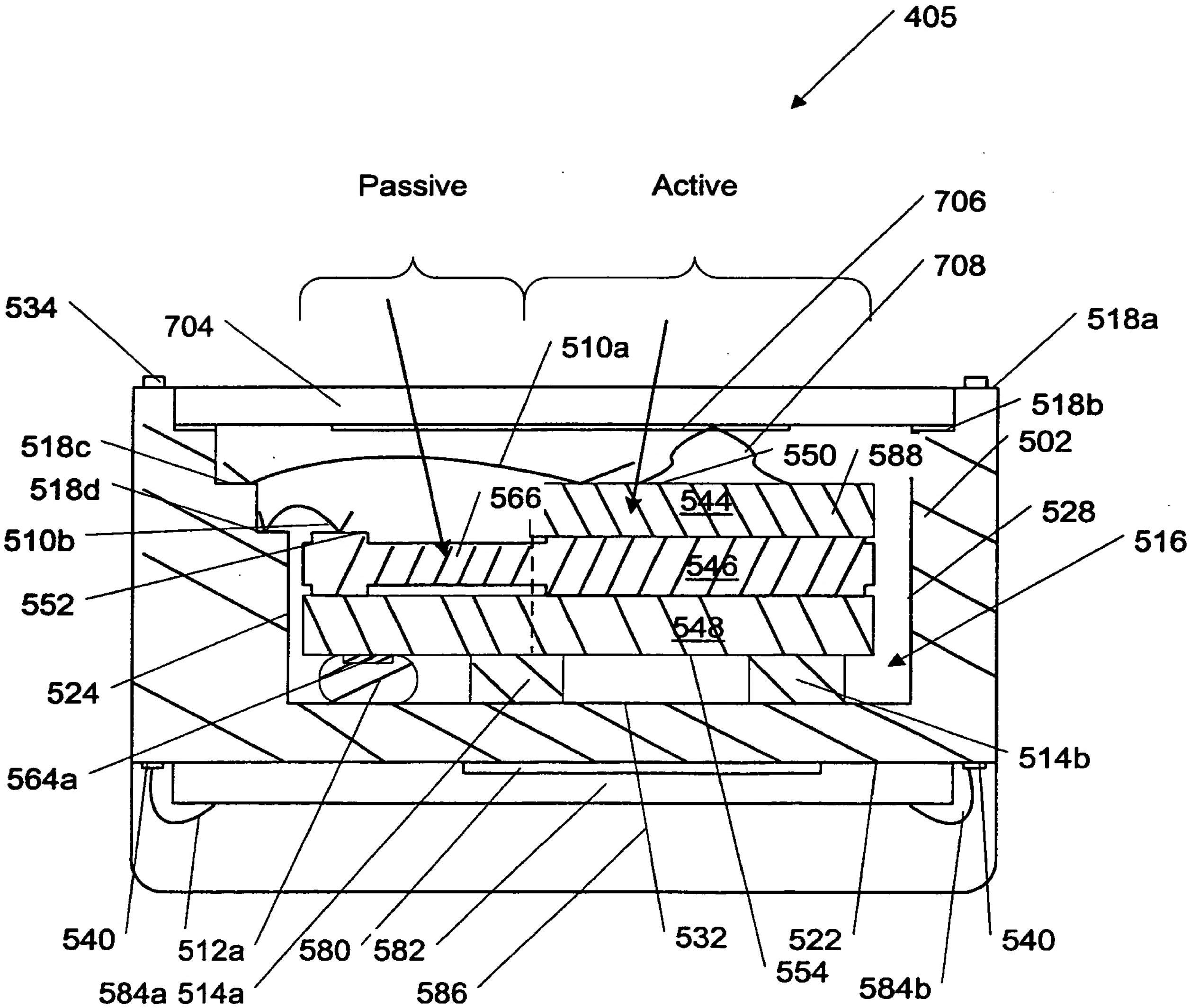


FIGURE 7A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584b

FIGURE 7B

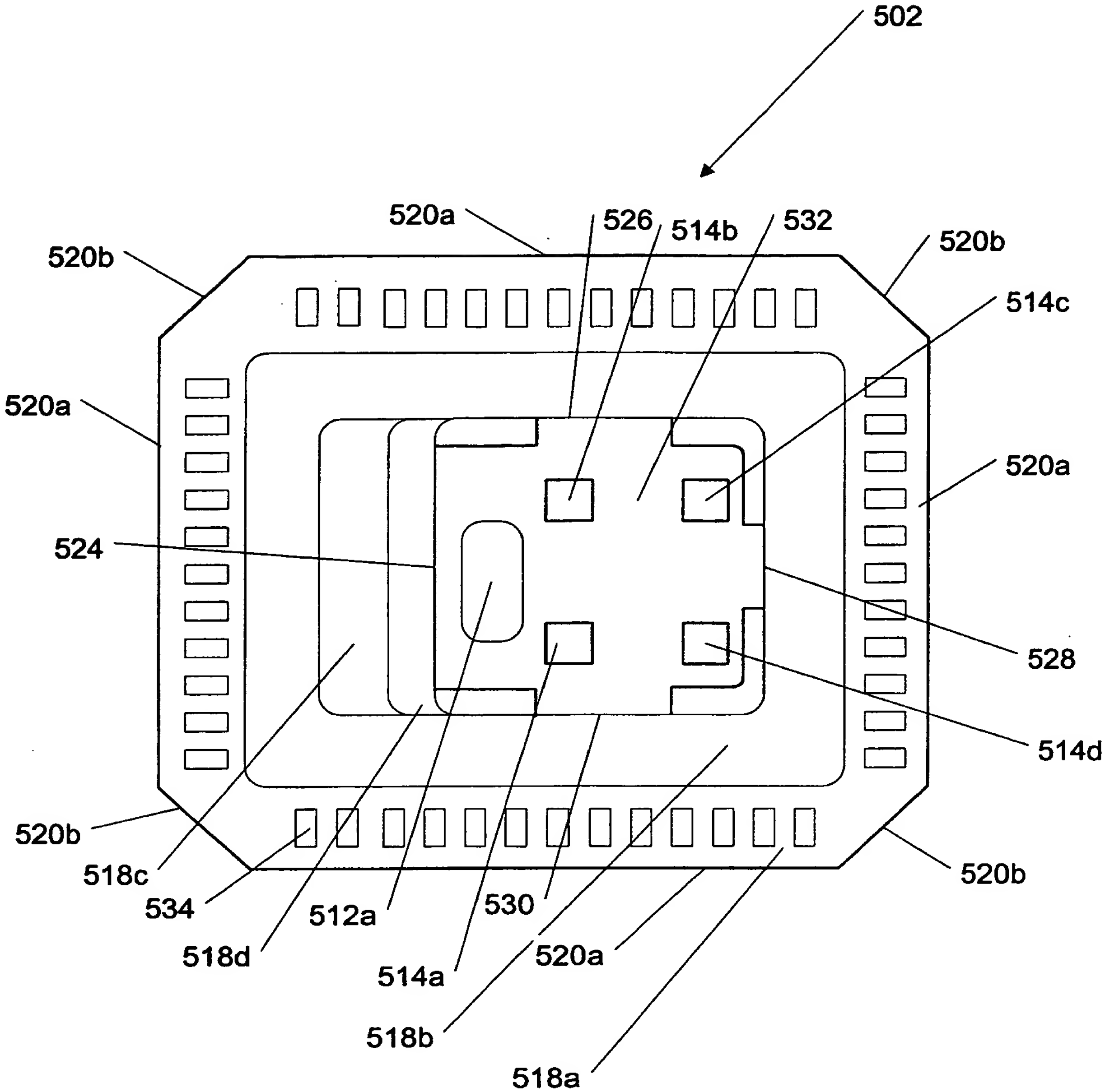
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FIGURE 7C

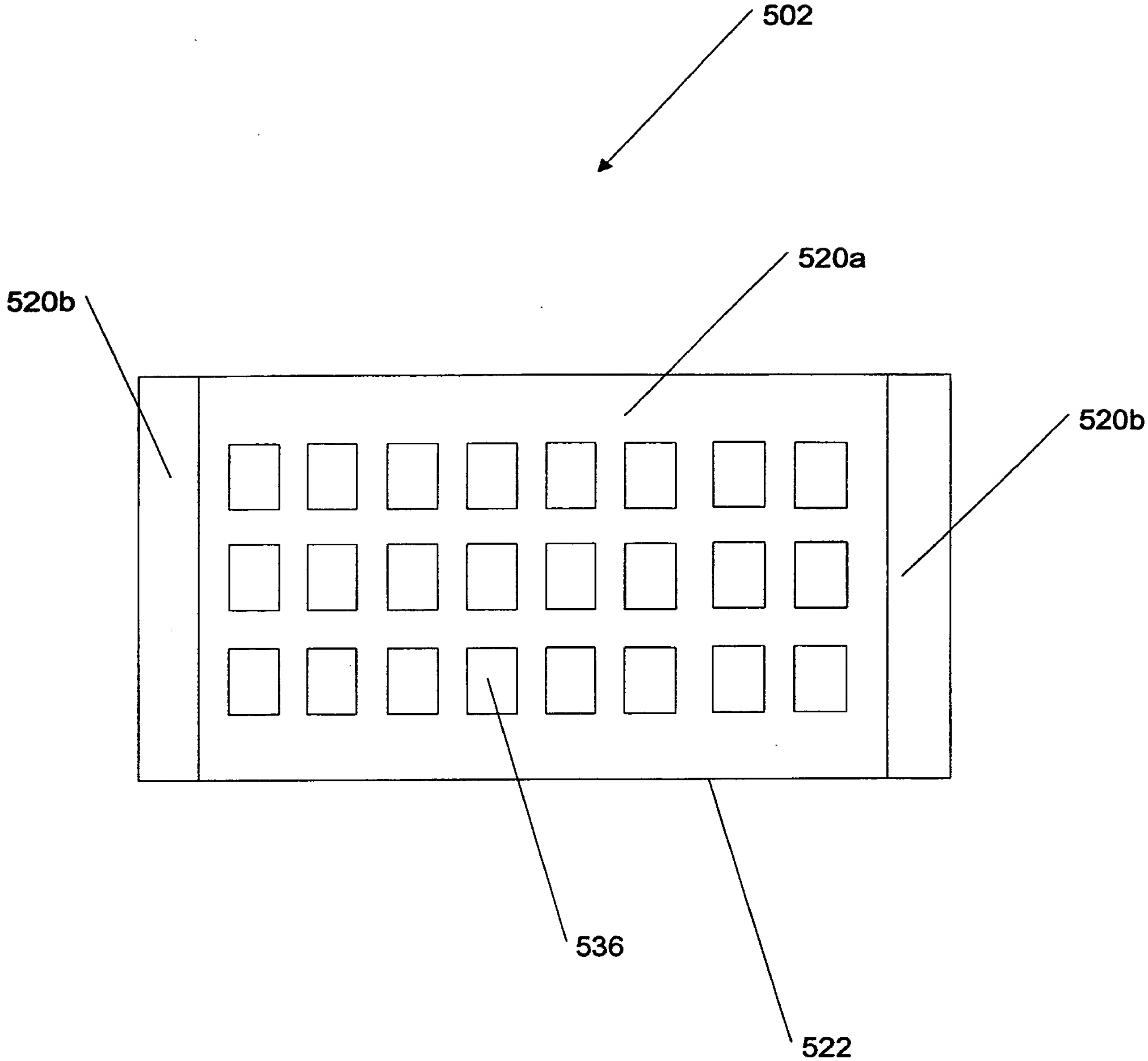

FIGURE 7D

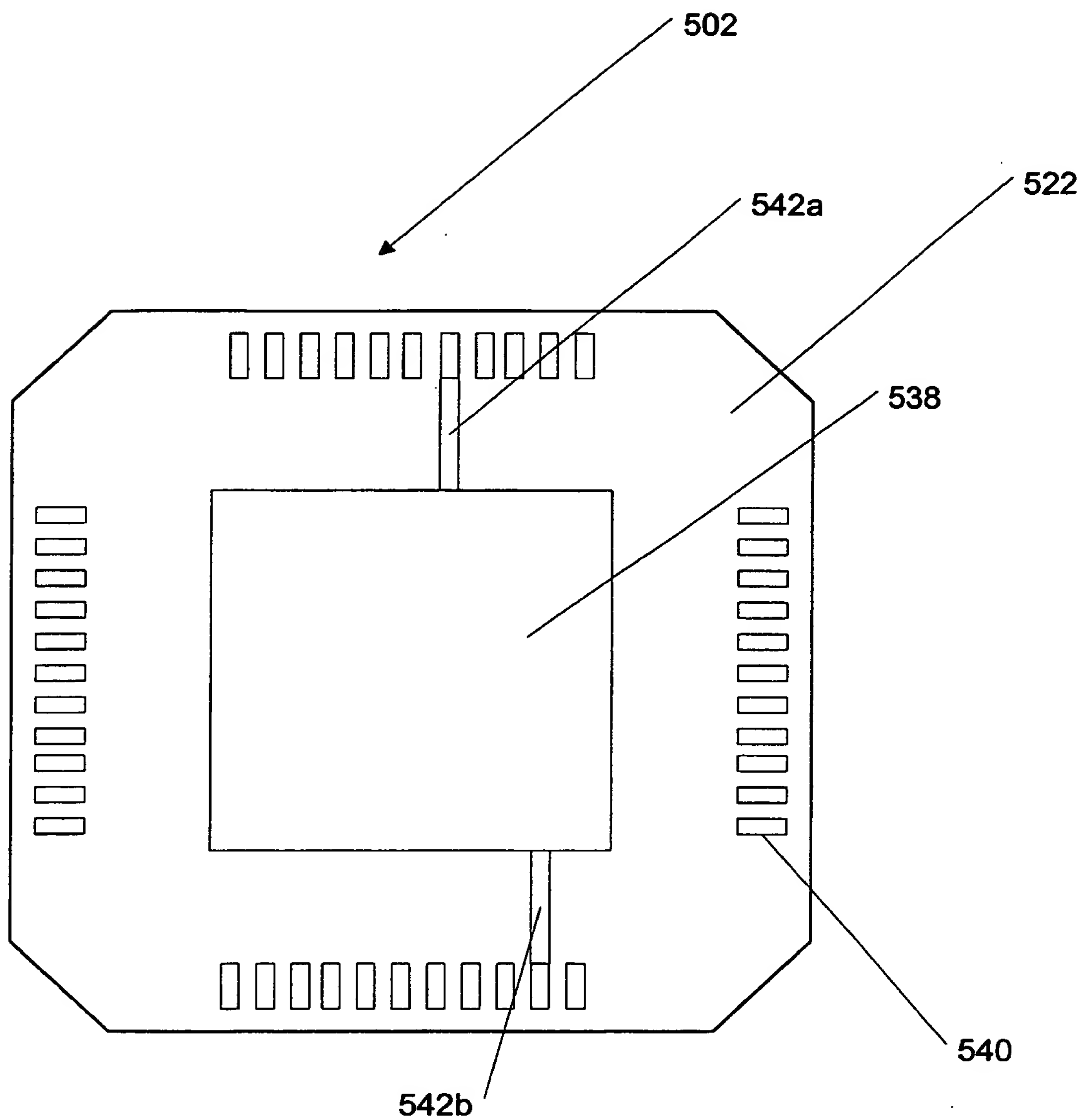

FIGURE 7E

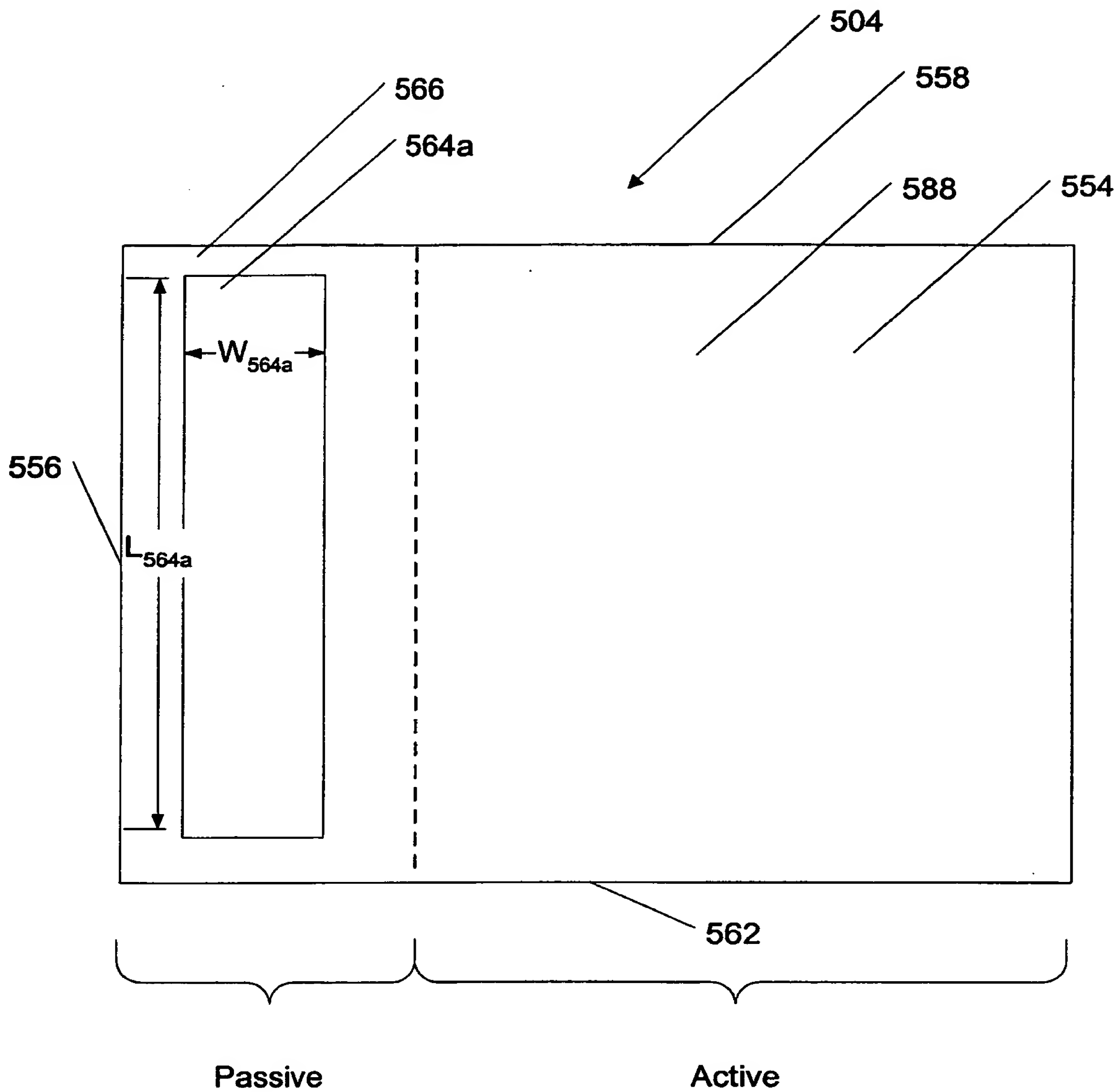

FIGURE 7F

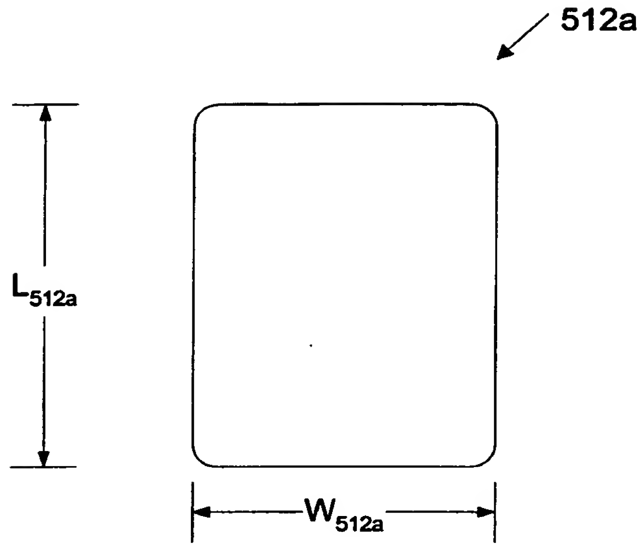

FIGURE 7G

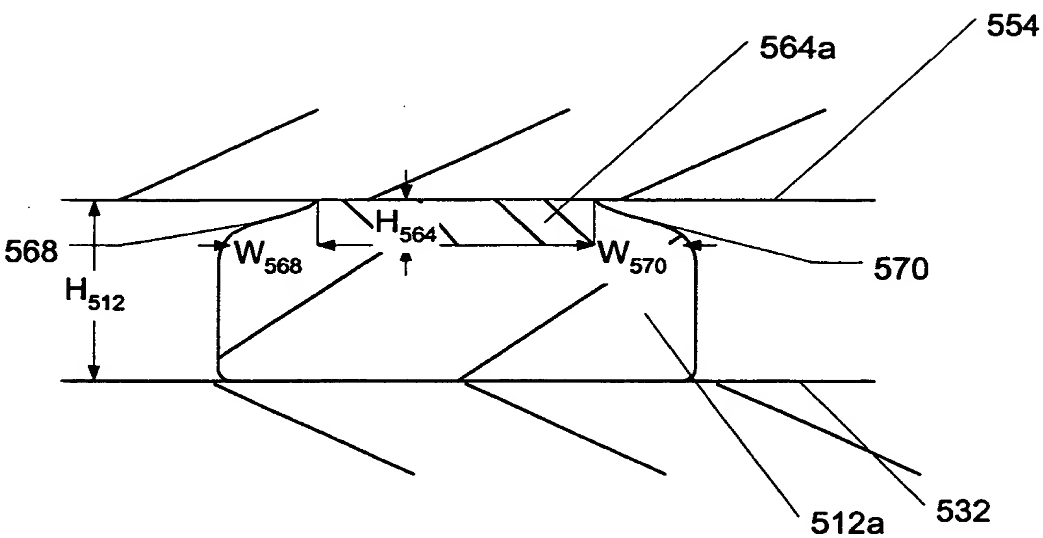

FIGURE 7H

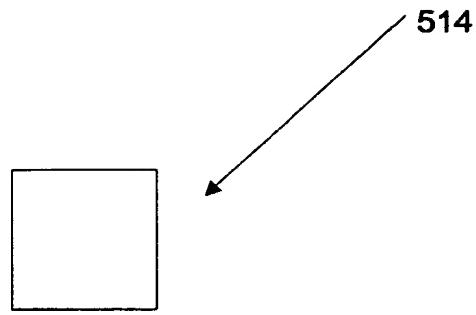

FIGURE 7I

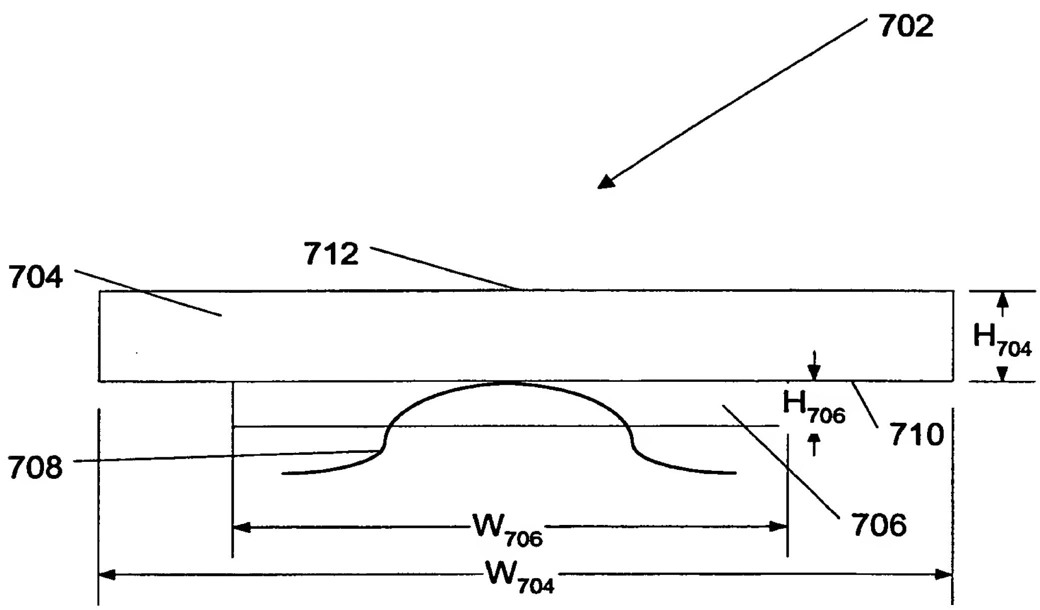

FIGURE 7J

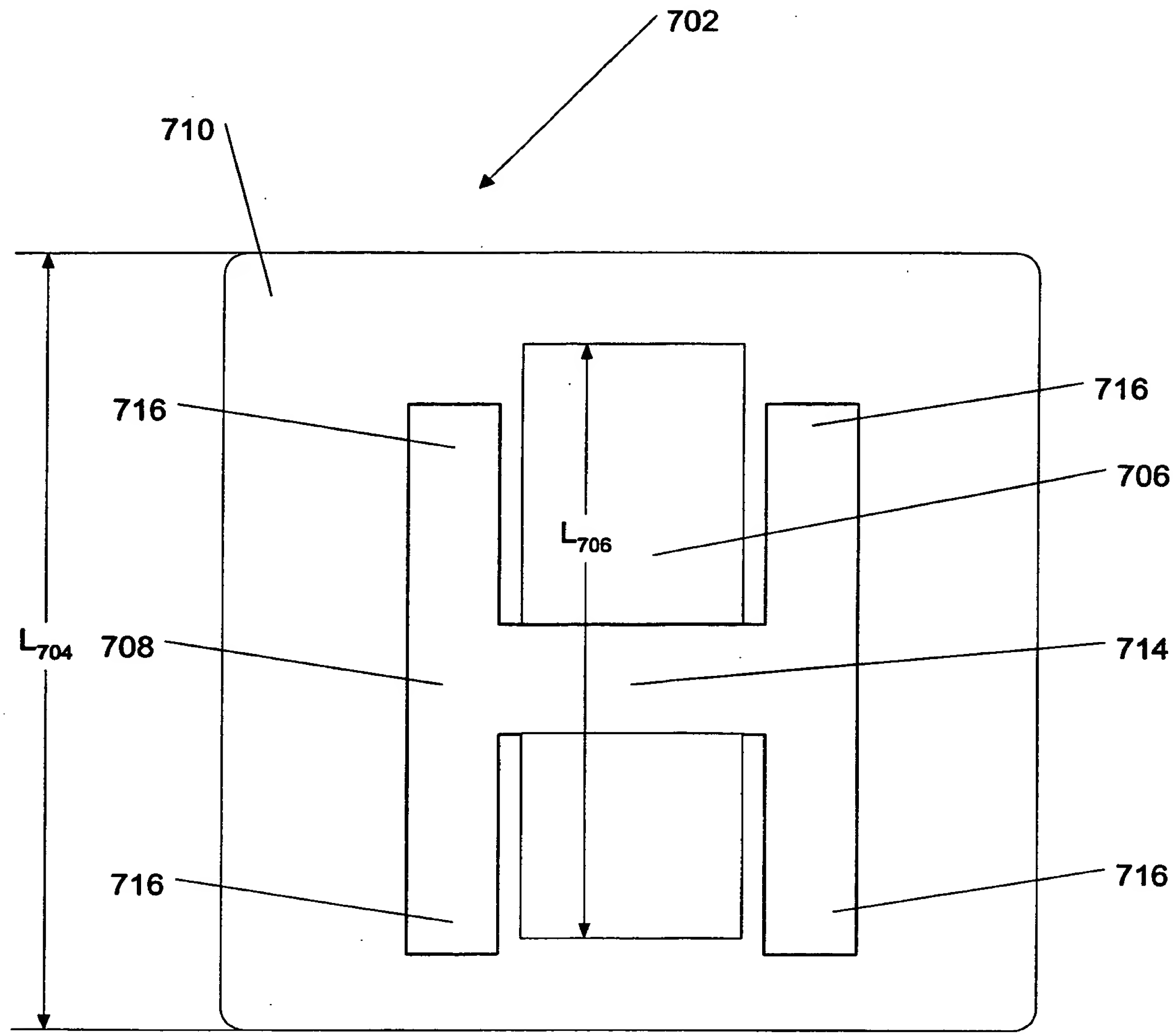

FIGURE 7K

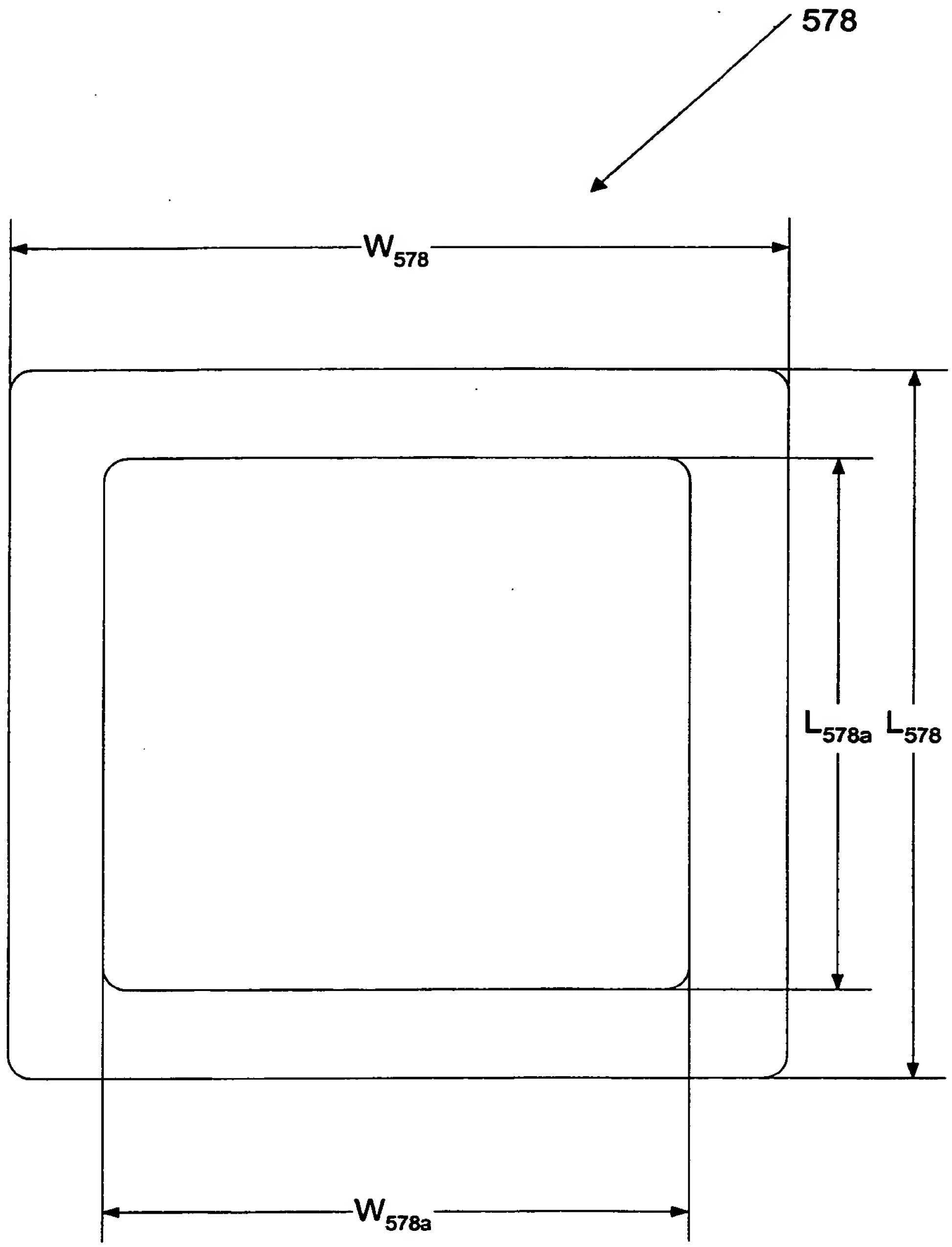

FIGURE 7L

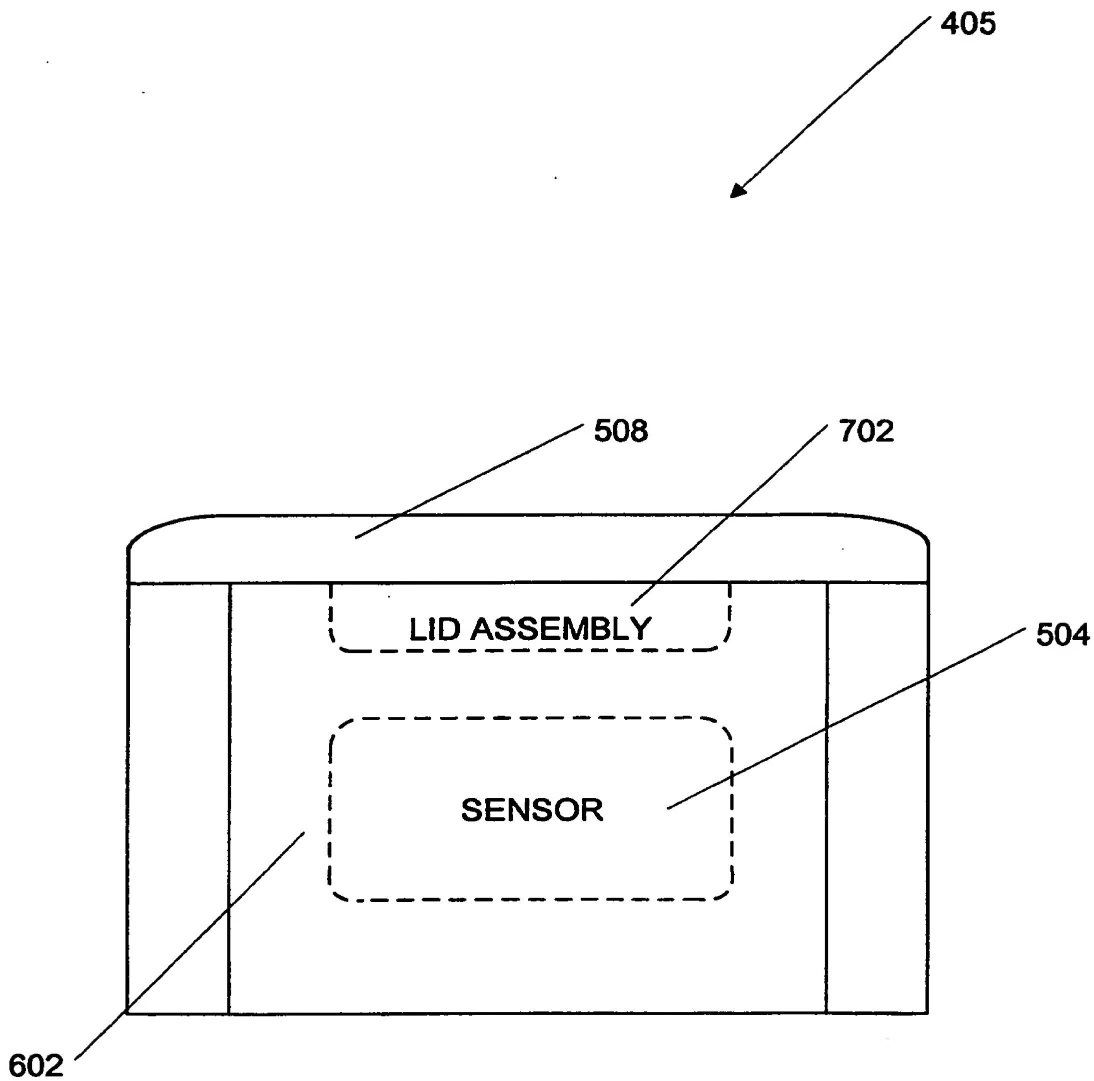

FIGURE 8A

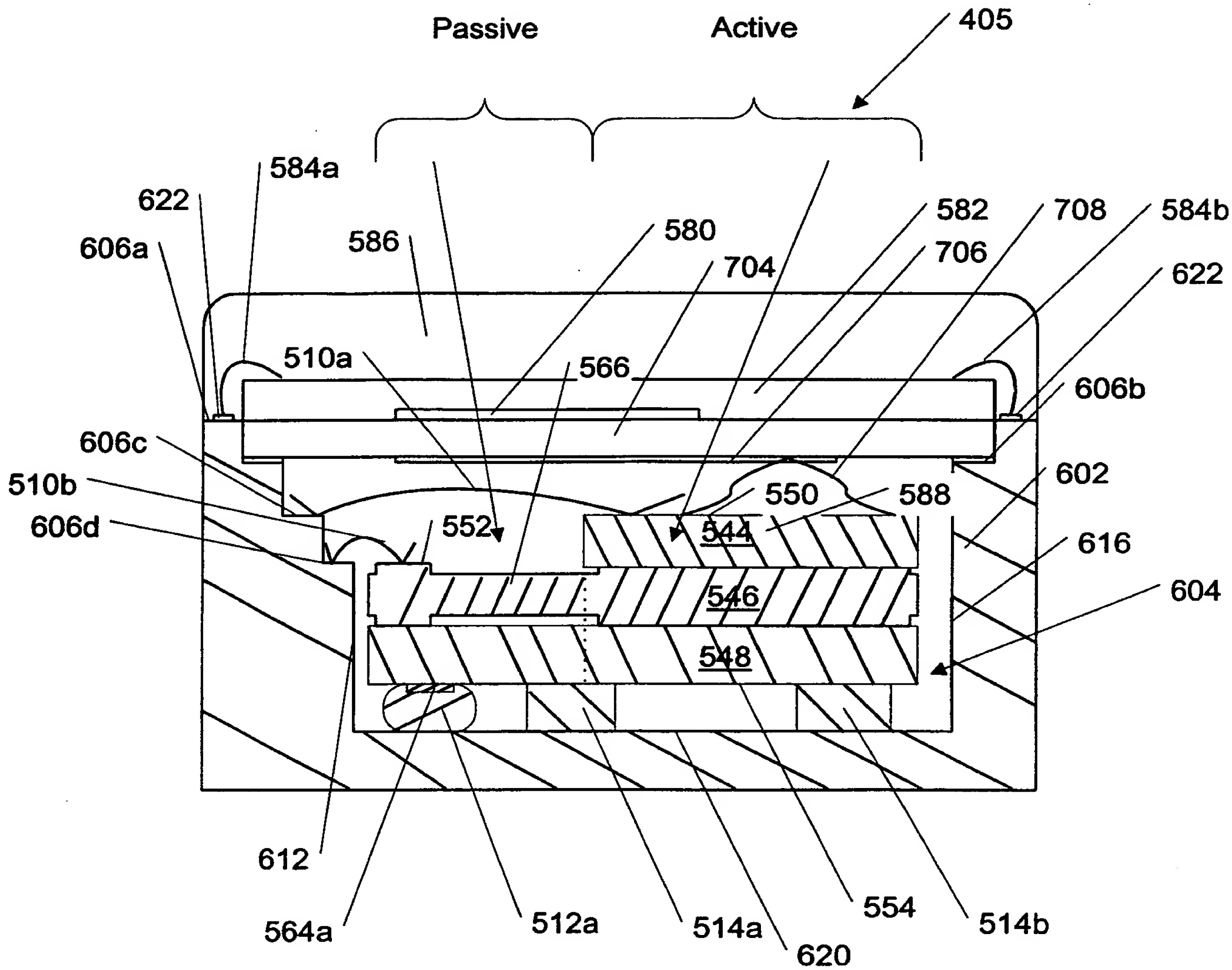
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FIGURE 8B

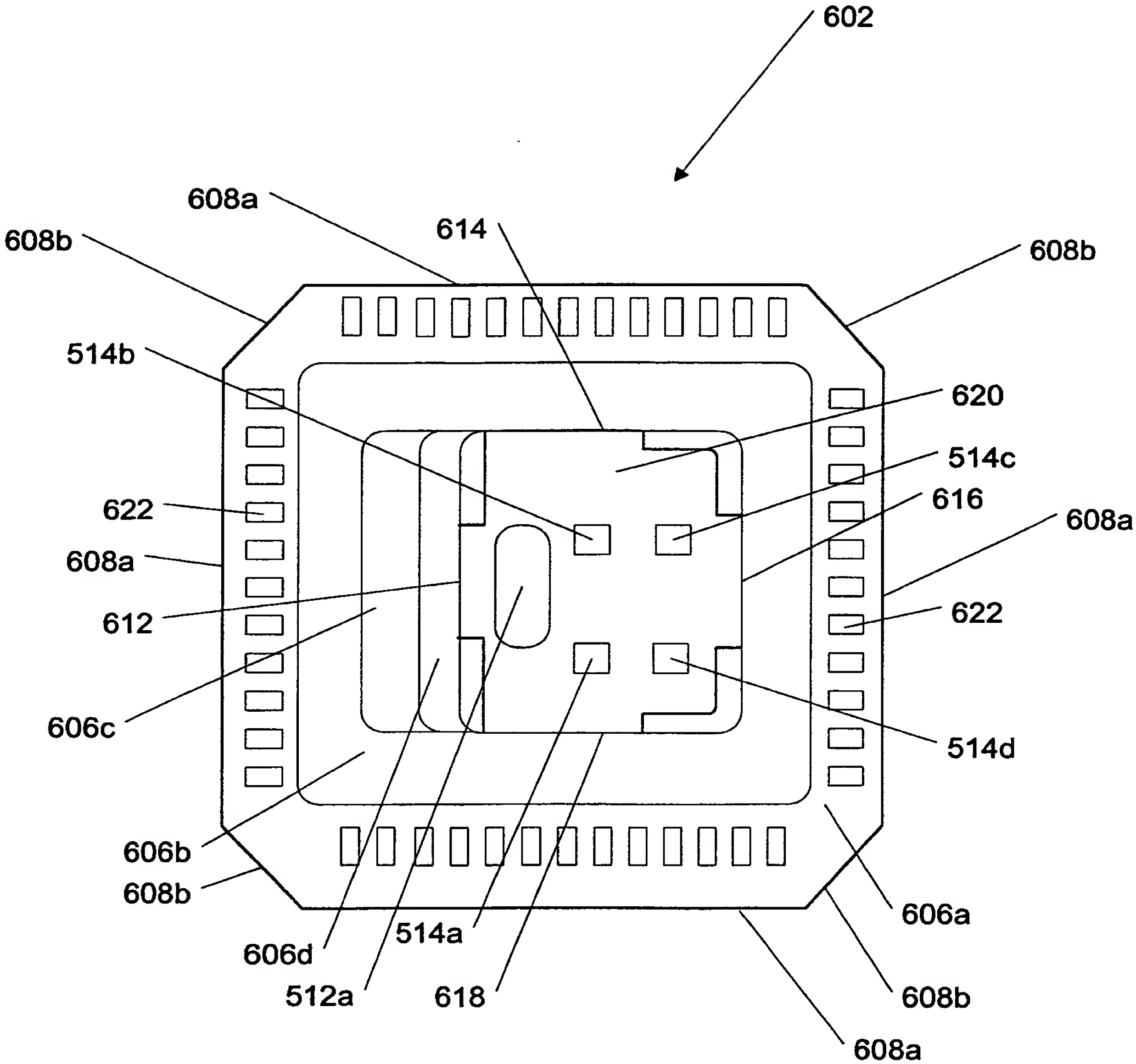

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FIGURE 8C

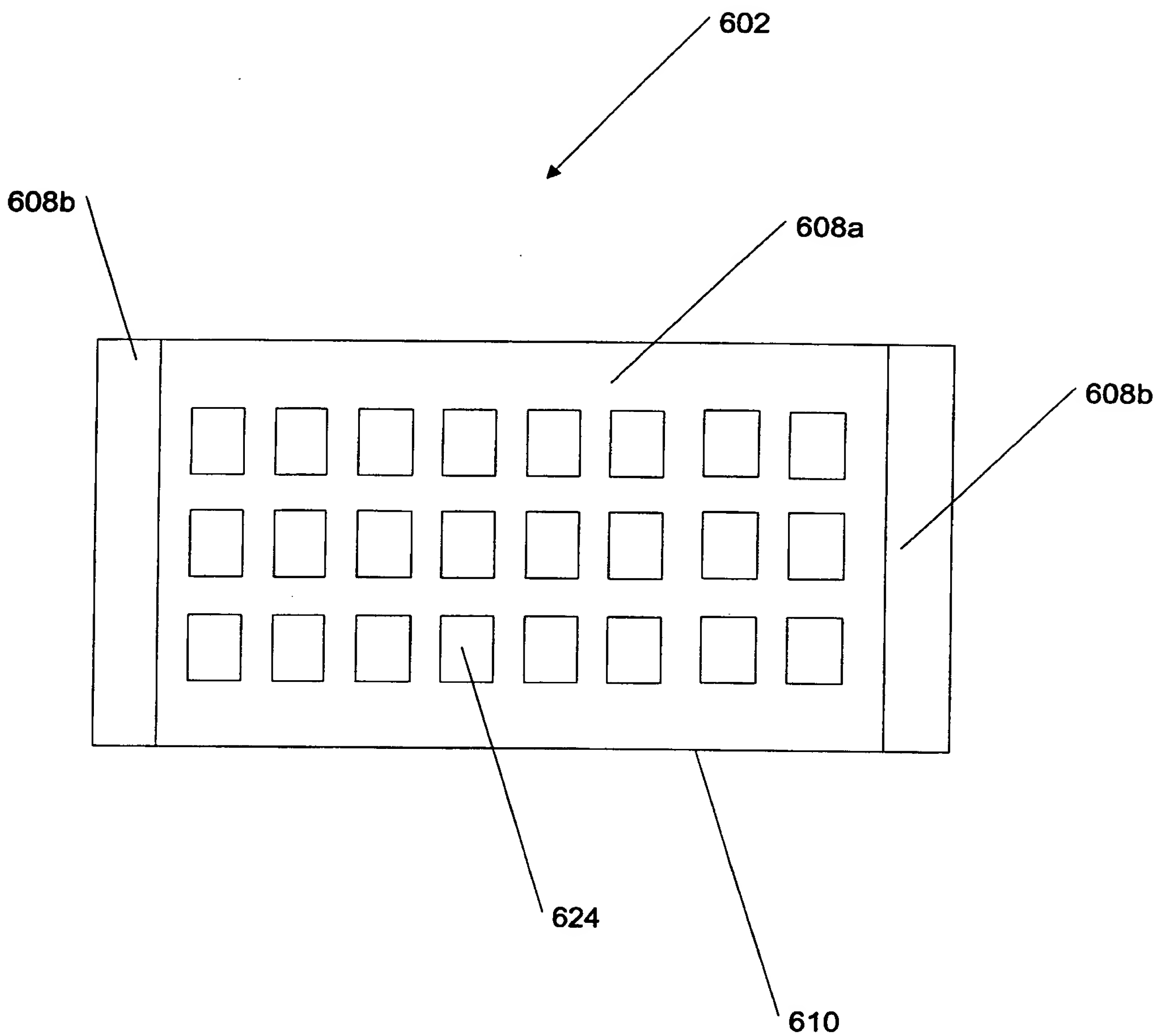

FIGURE 8D

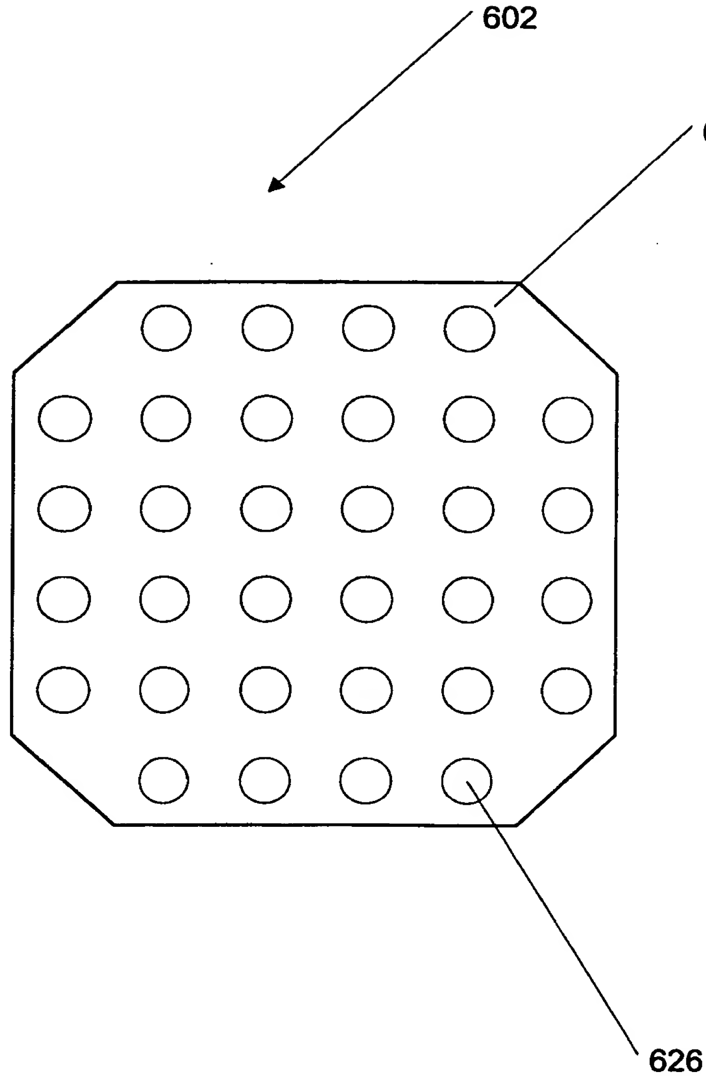

FIGURE 8E

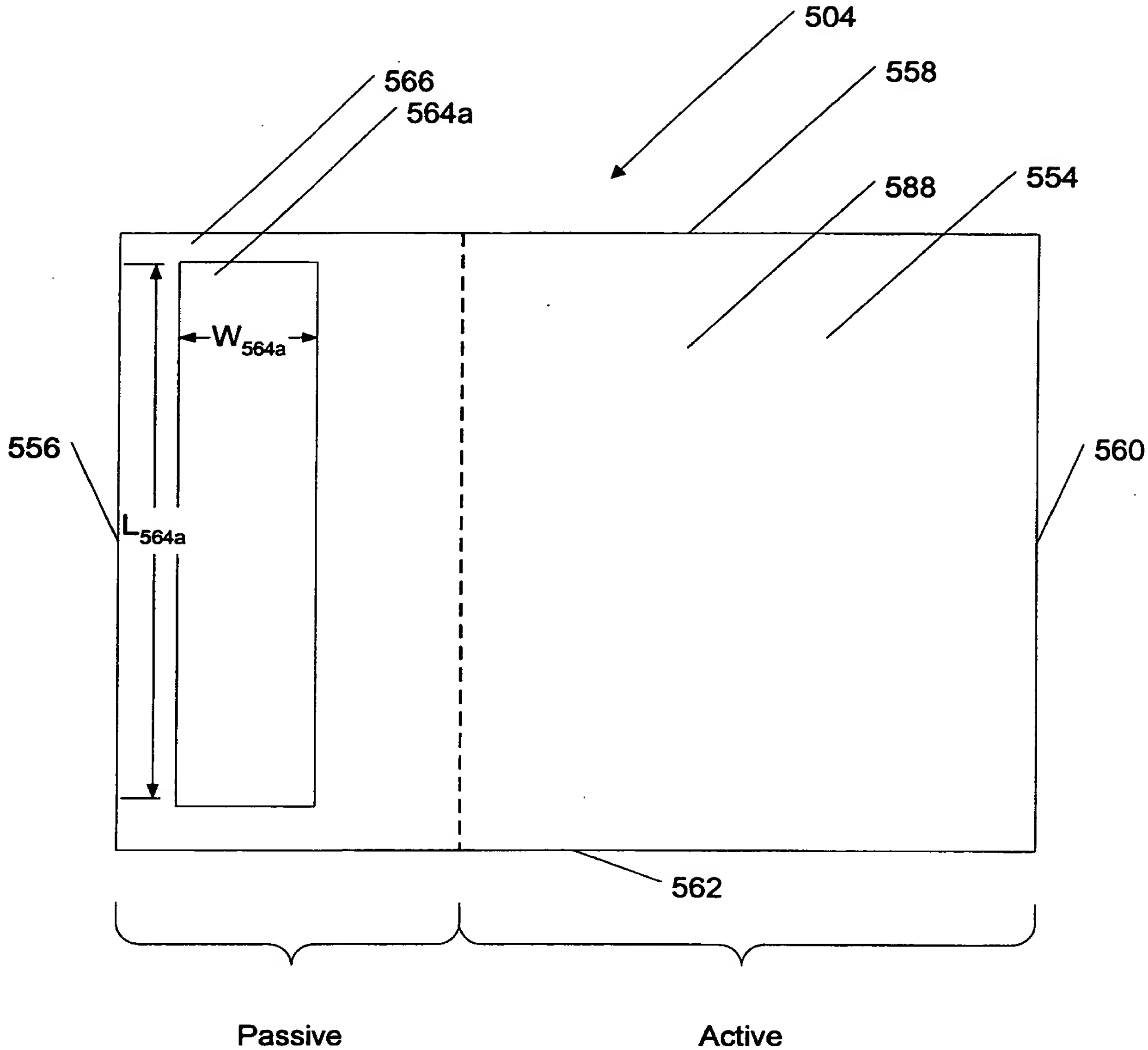
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FIGURE 8F

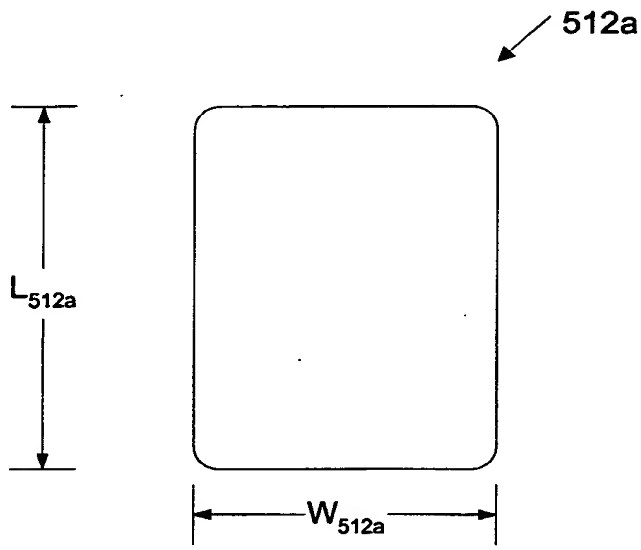

FIGURE 8G

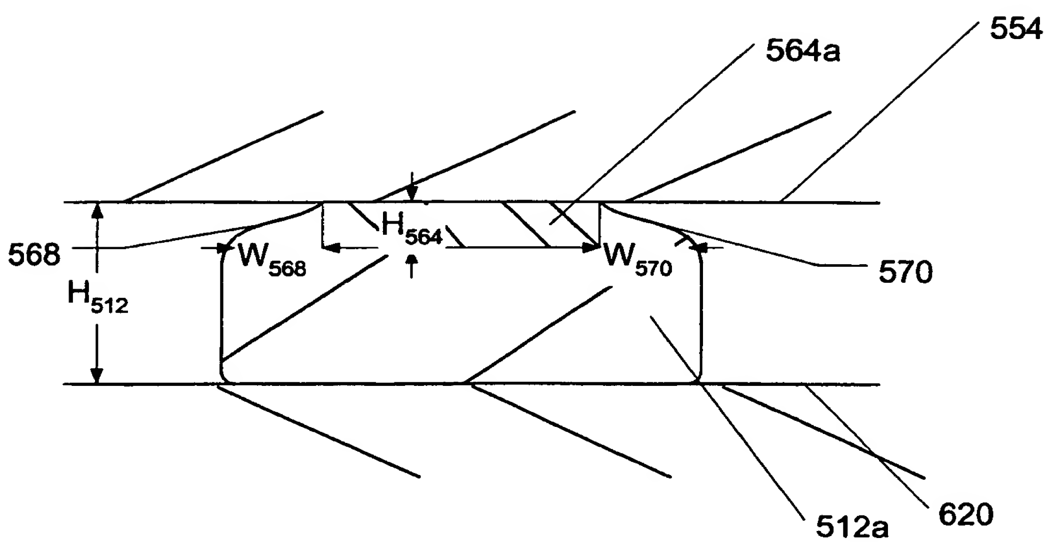

FIGURE 8H

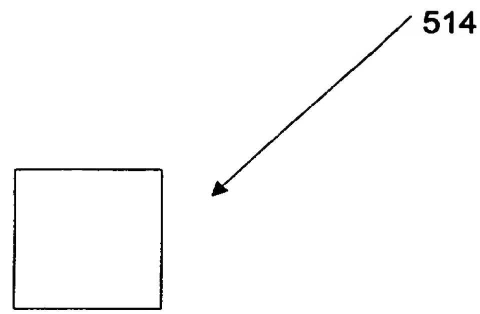

FIGURE 8I

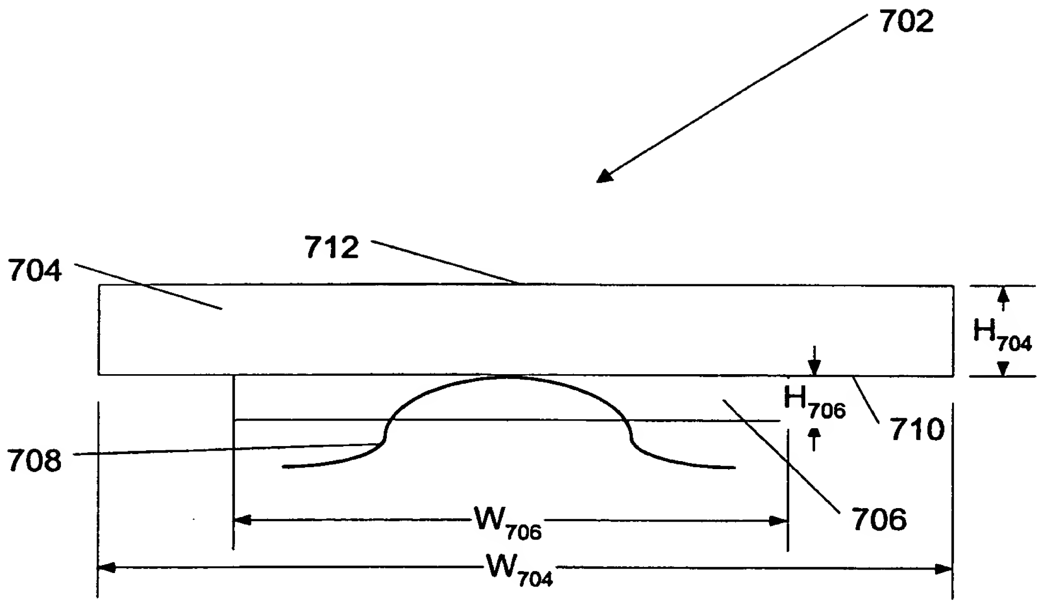

FIGURE 8J

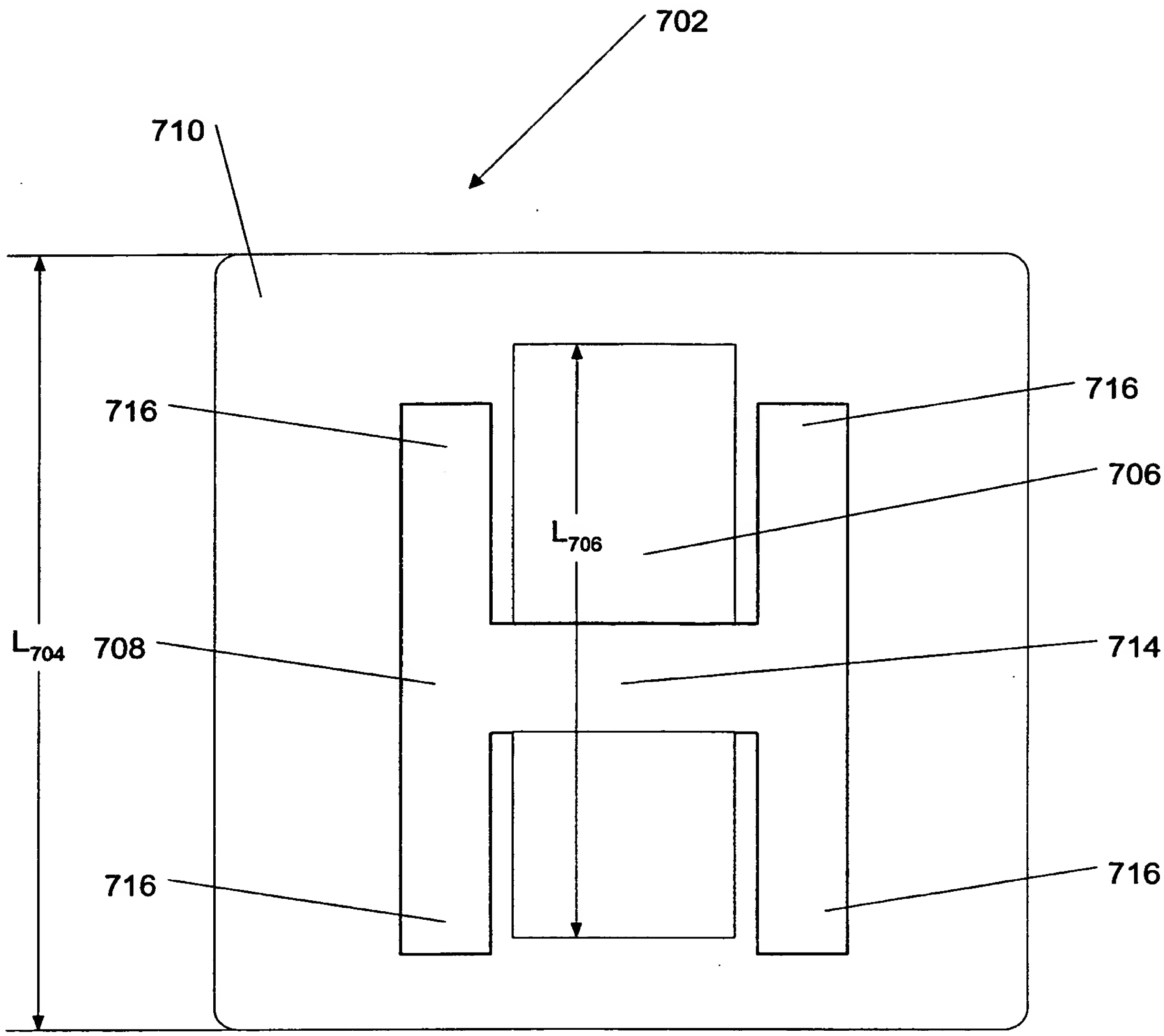

FIGURE 8K

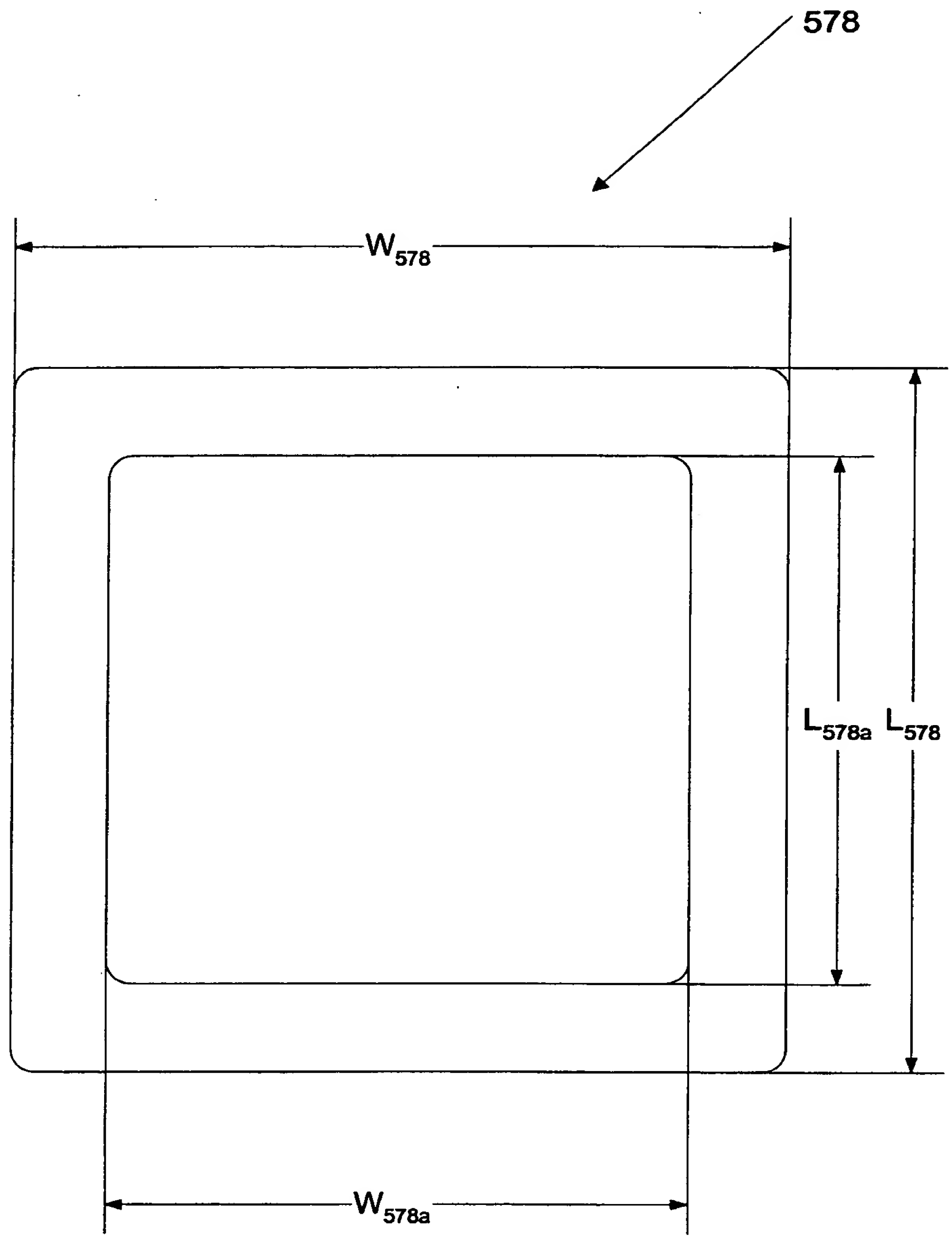

FIGURE 8L

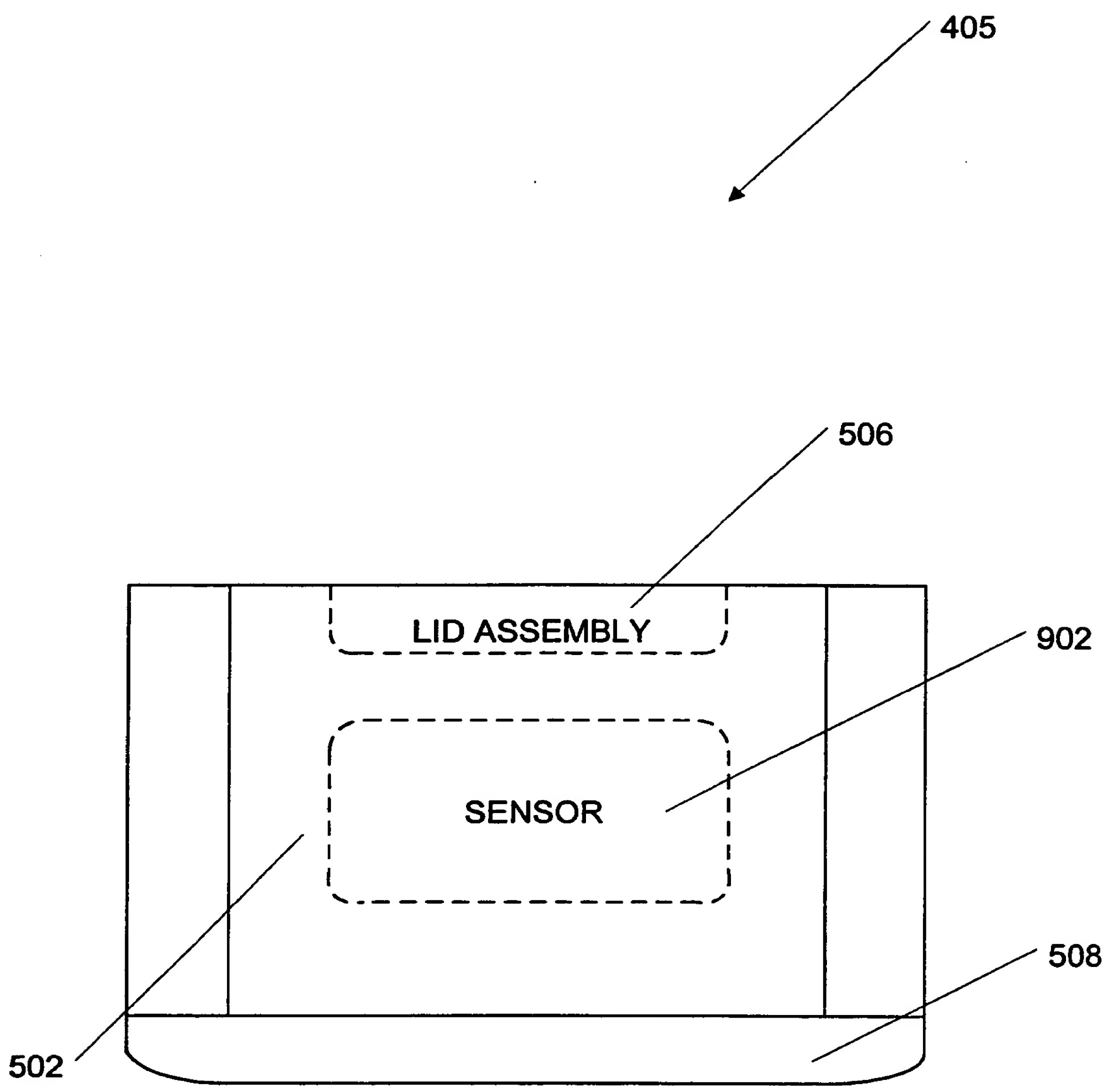

FIGURE 9A

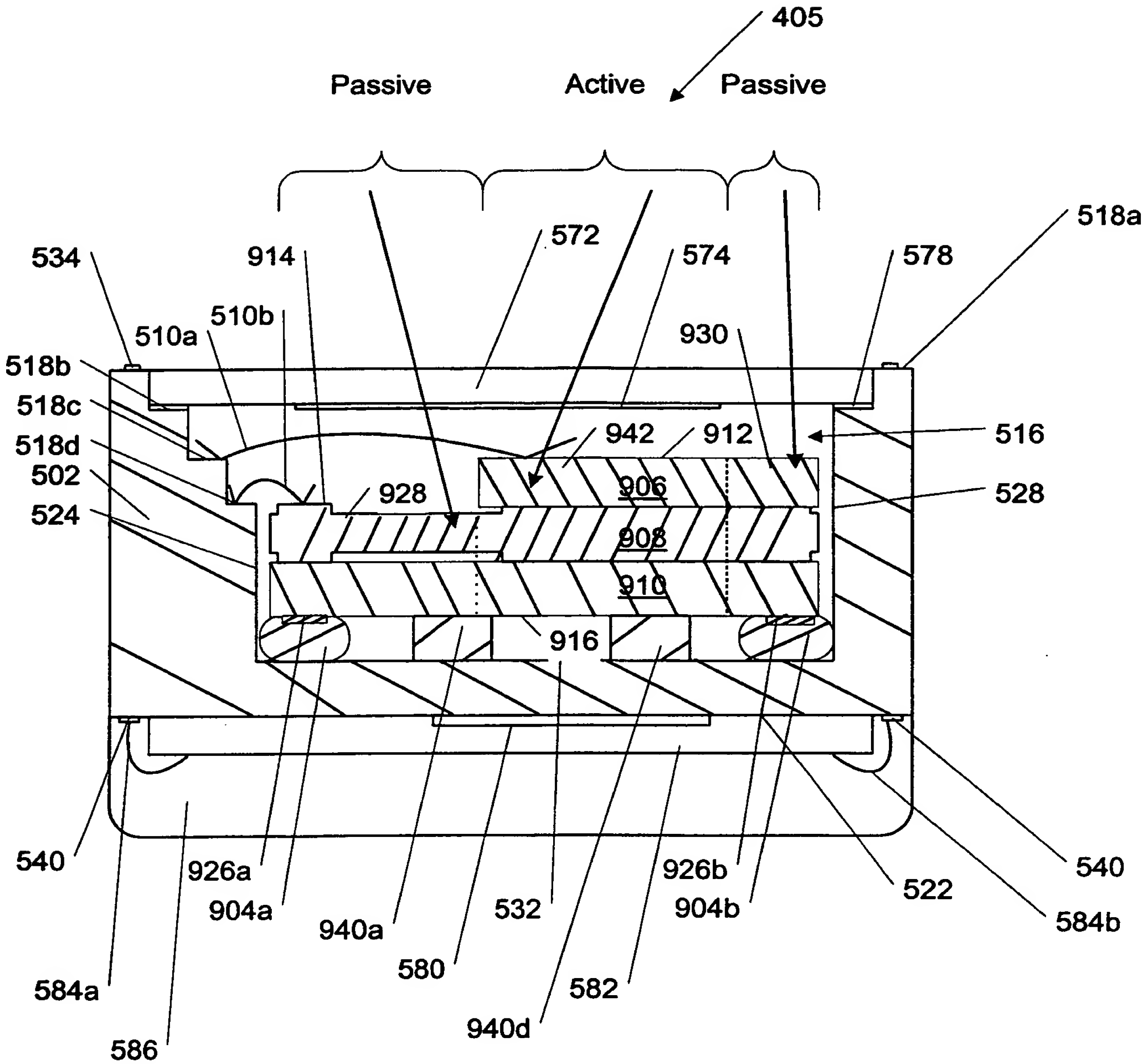
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FIGURE 9B

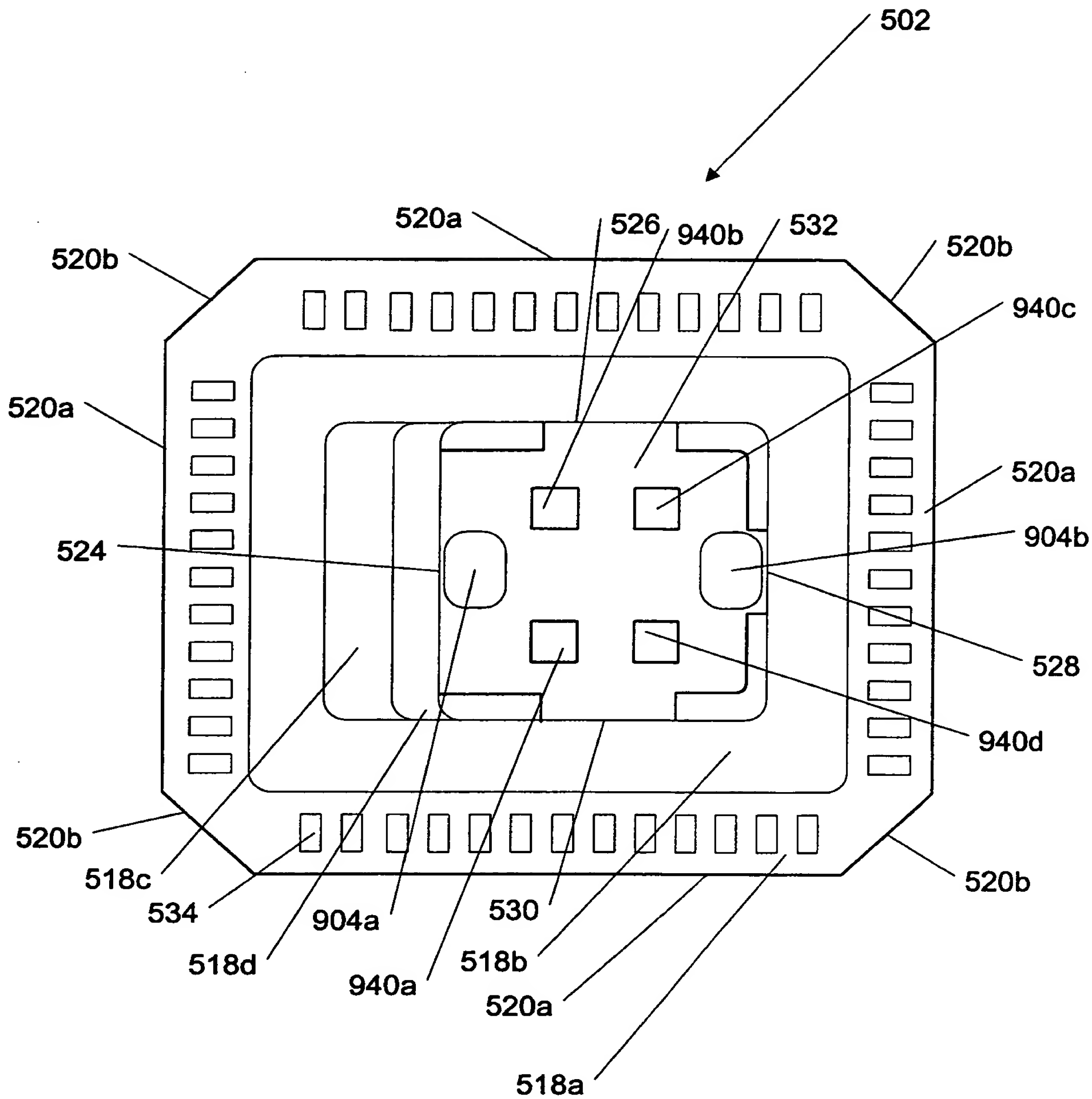
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FIGURE 9C

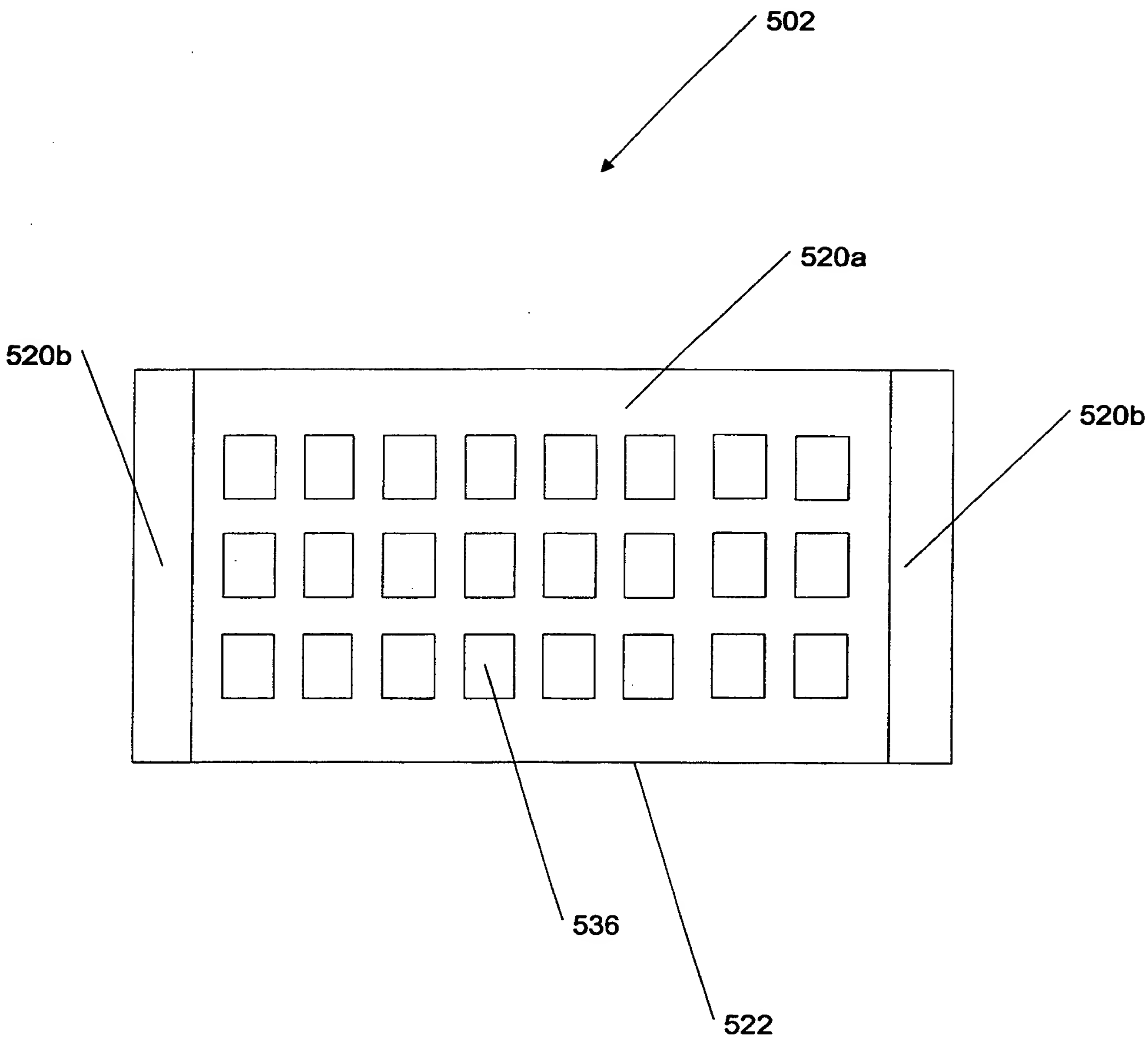


FIGURE 9D

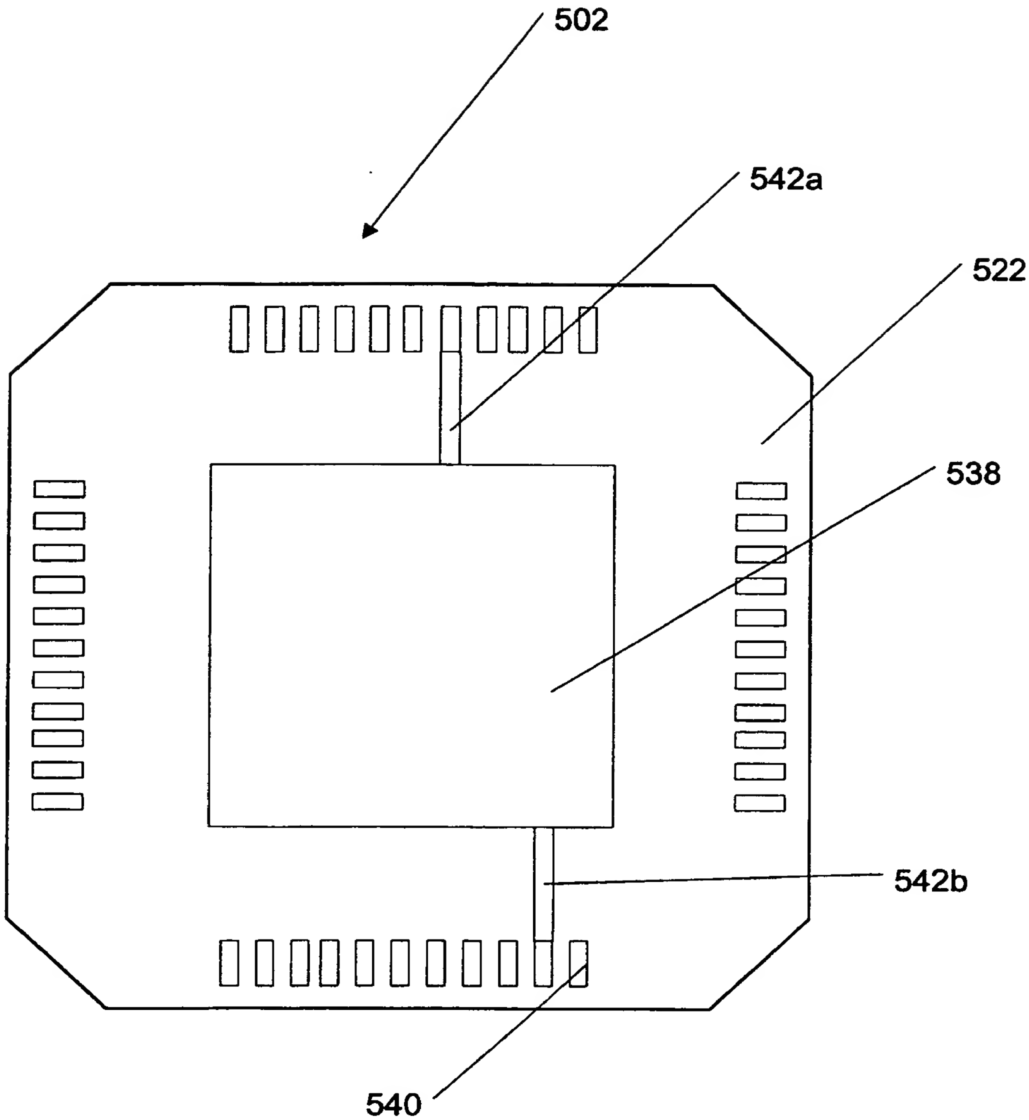
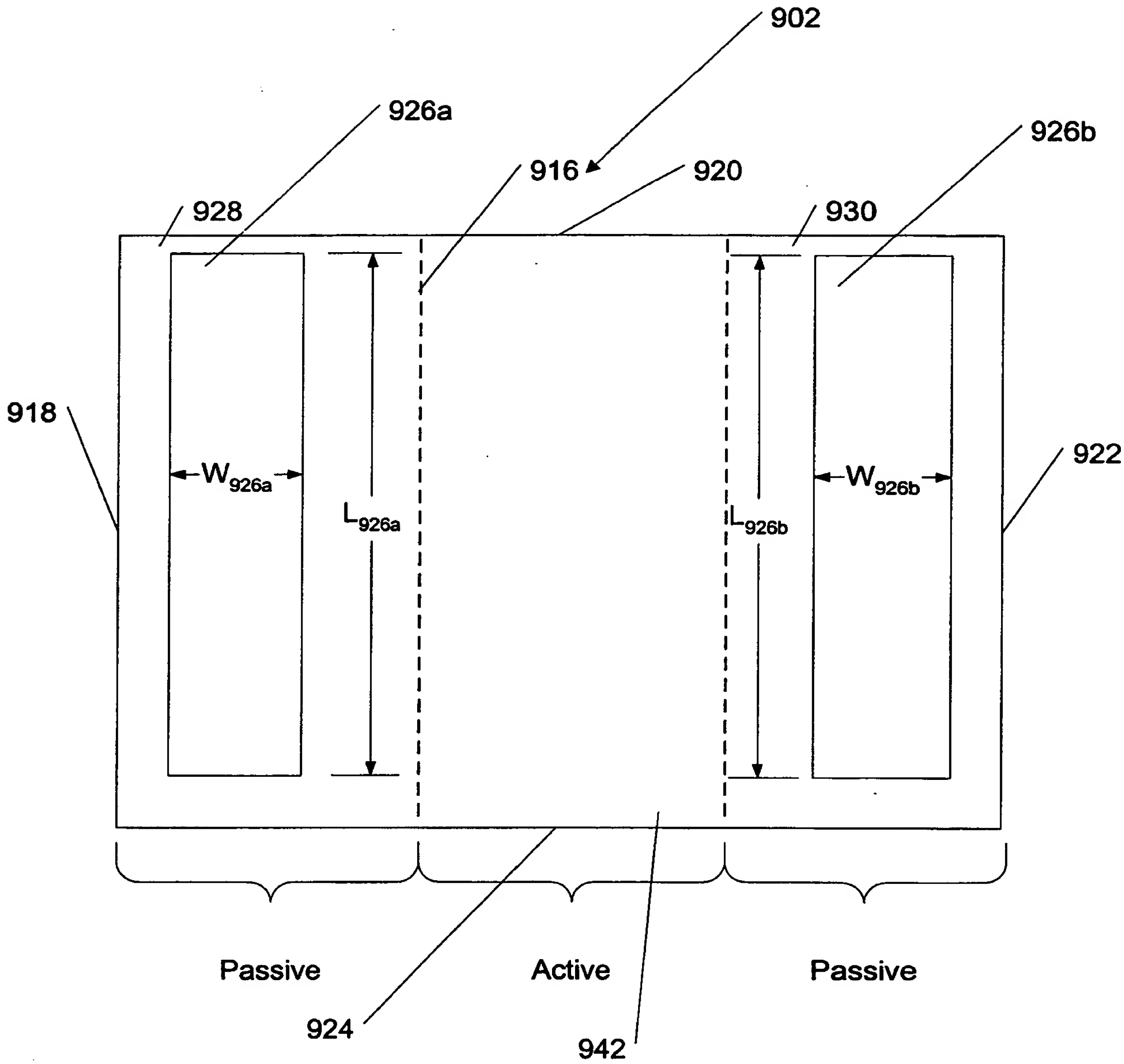


FIGURE 9E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Active
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FIGURE 9F

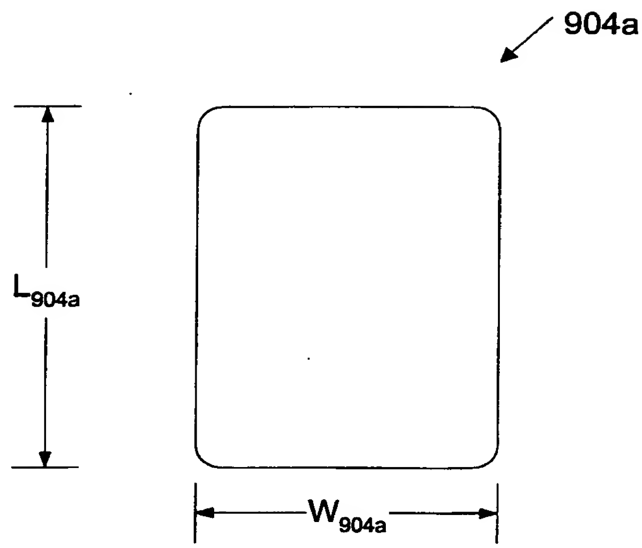

FIGURE 9G

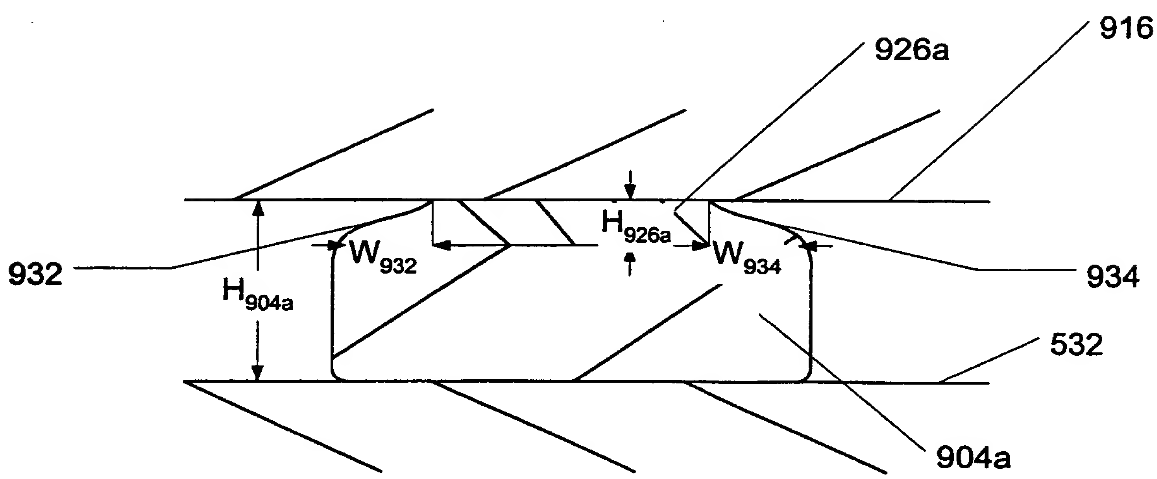

FIGURE 9H

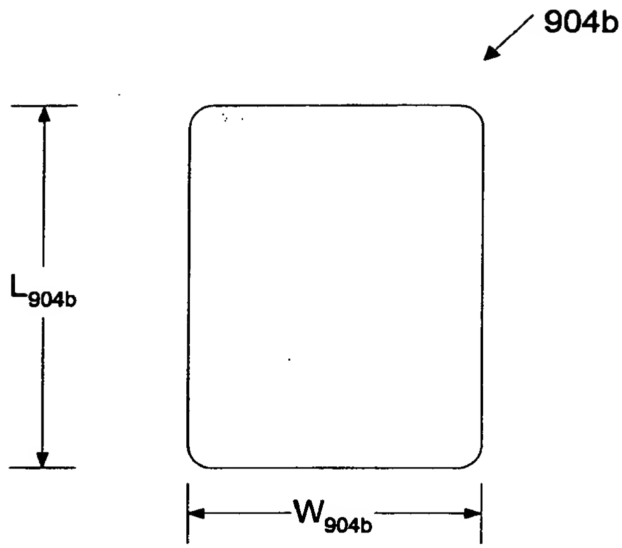

FIGURE 9I

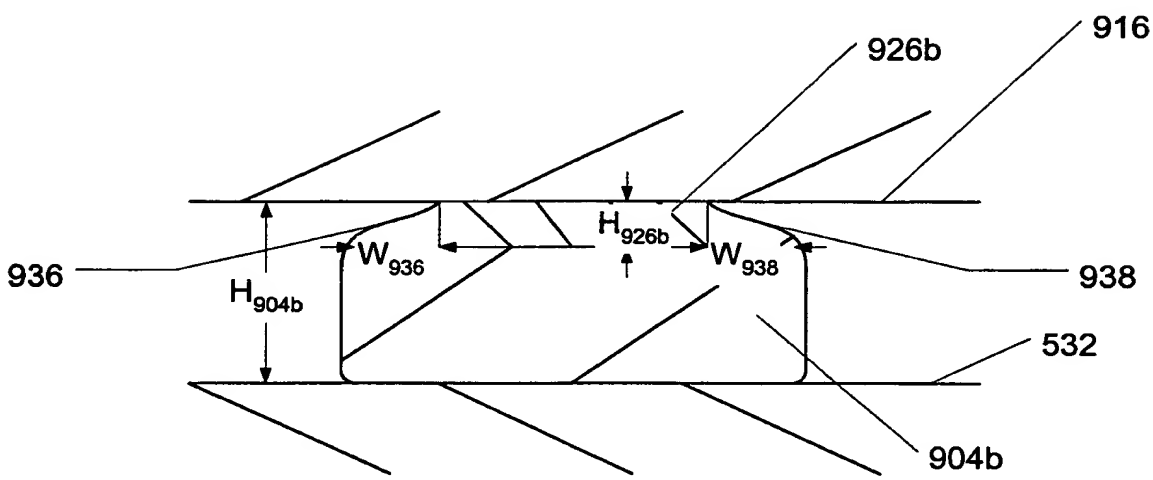

FIGURE 9J

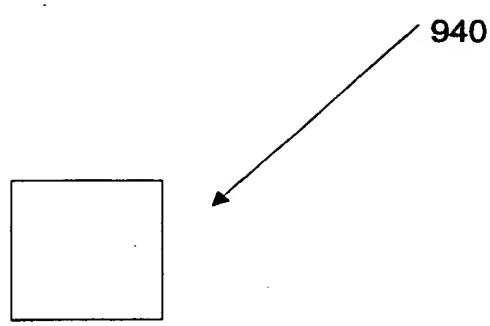

FIGURE 9K

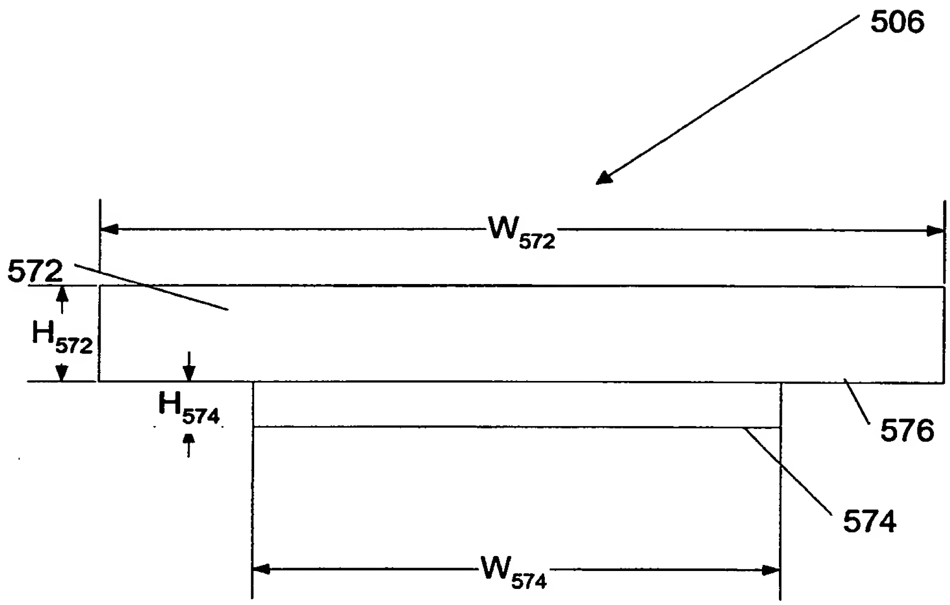

FIGURE 9L

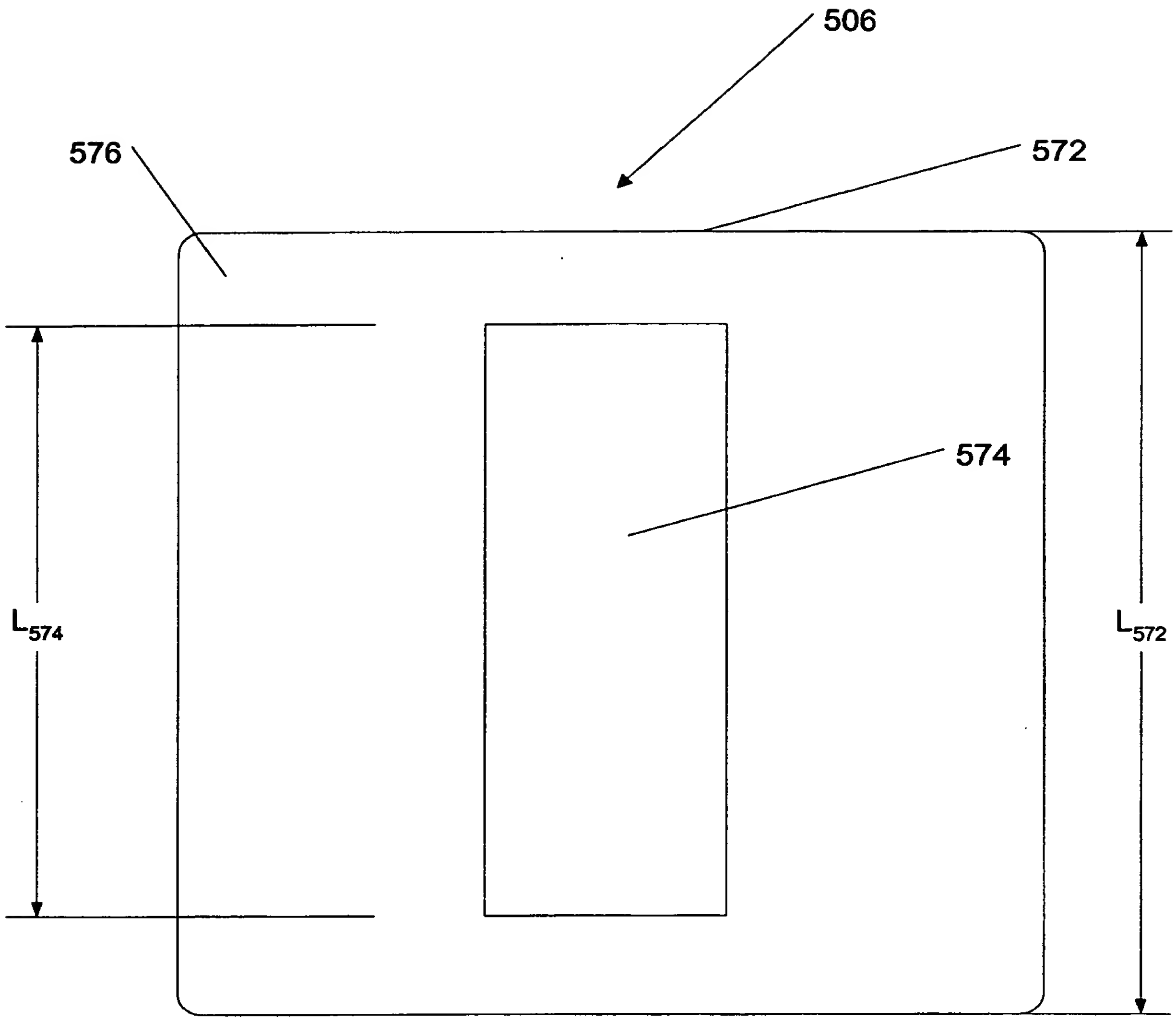

FIGURE 9M

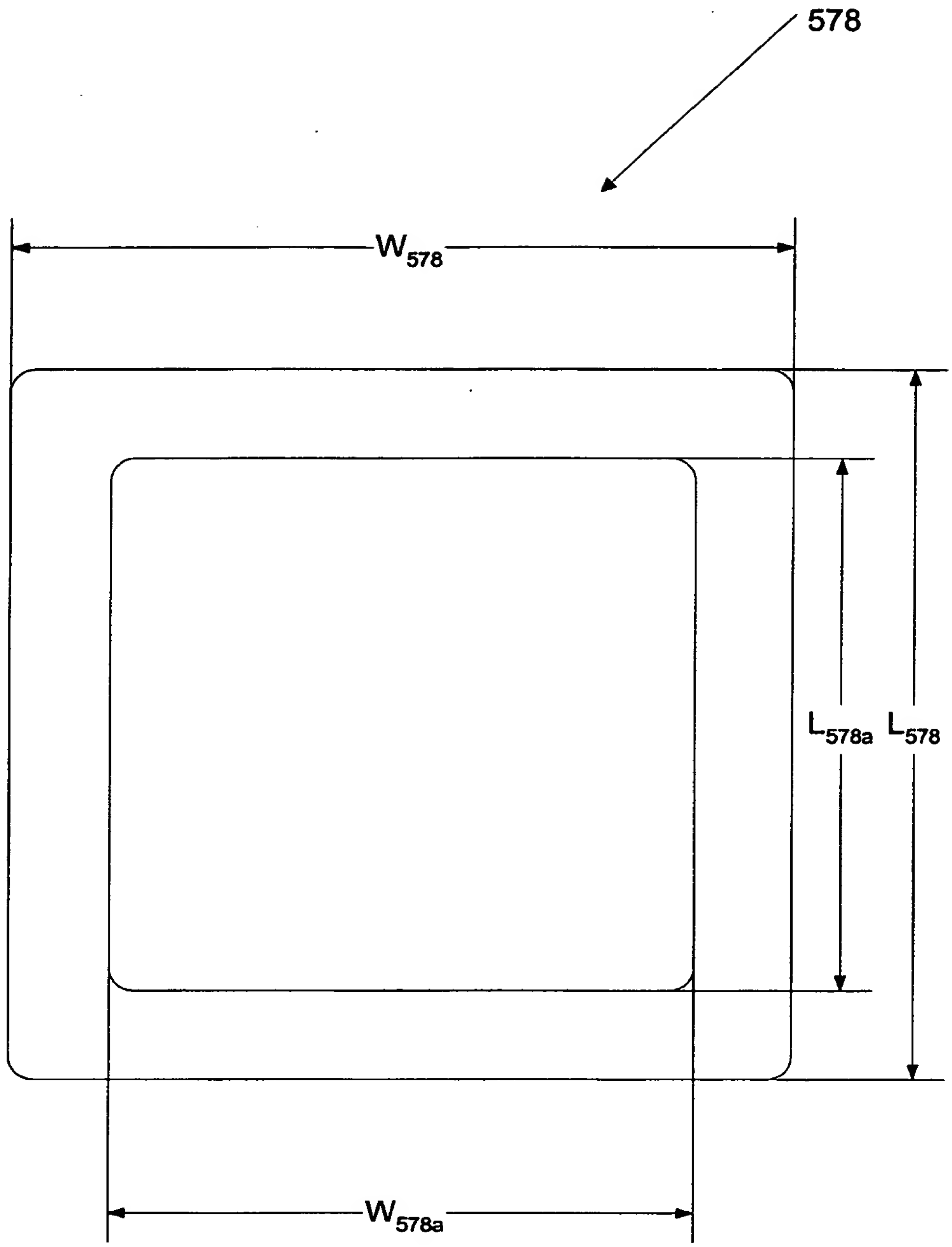

FIGURE 9N

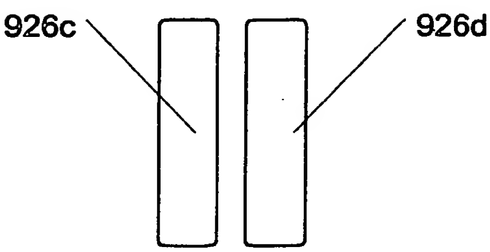

FIGURE 9O

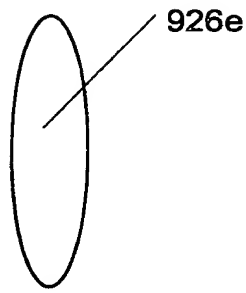

FIGURE 9P

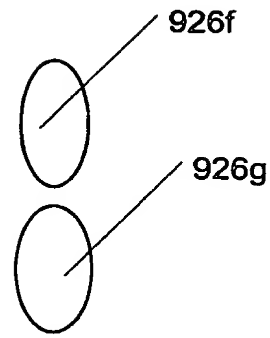

FIGURE 9Q

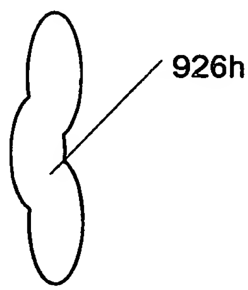

FIGURE 9R

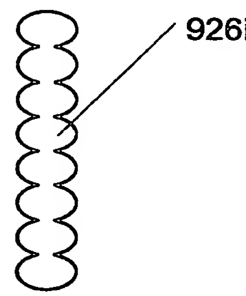

FIGURE 9S

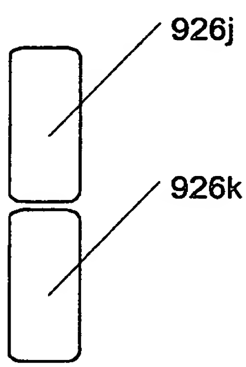

FIGURE 9T

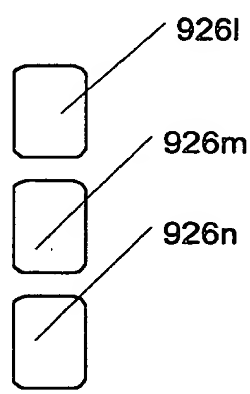

FIGURE 9U

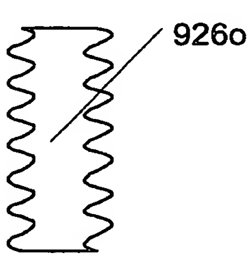

FIGURE 9V

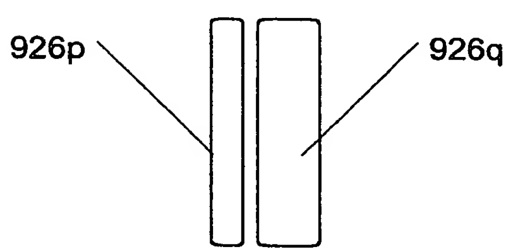

FIGURE 9W

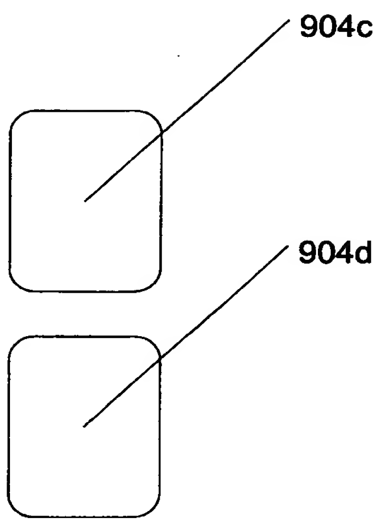

FIGURE 9X

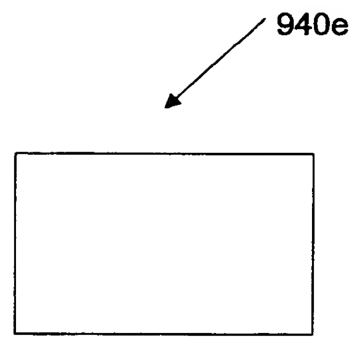

FIGURE 9Y

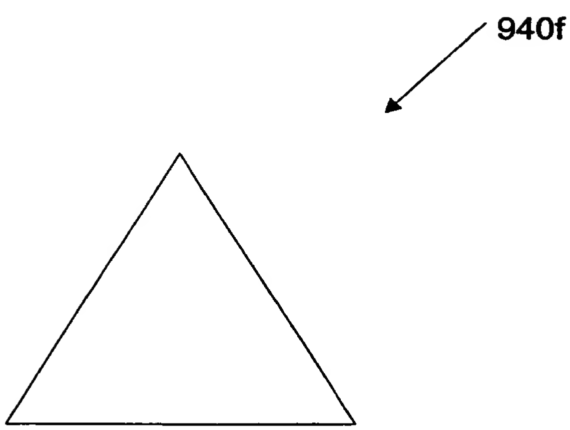

FIGURE 9Z

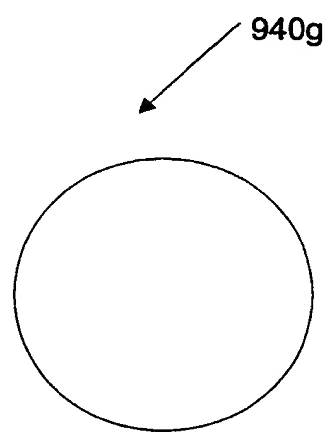

FIGURE 9AA

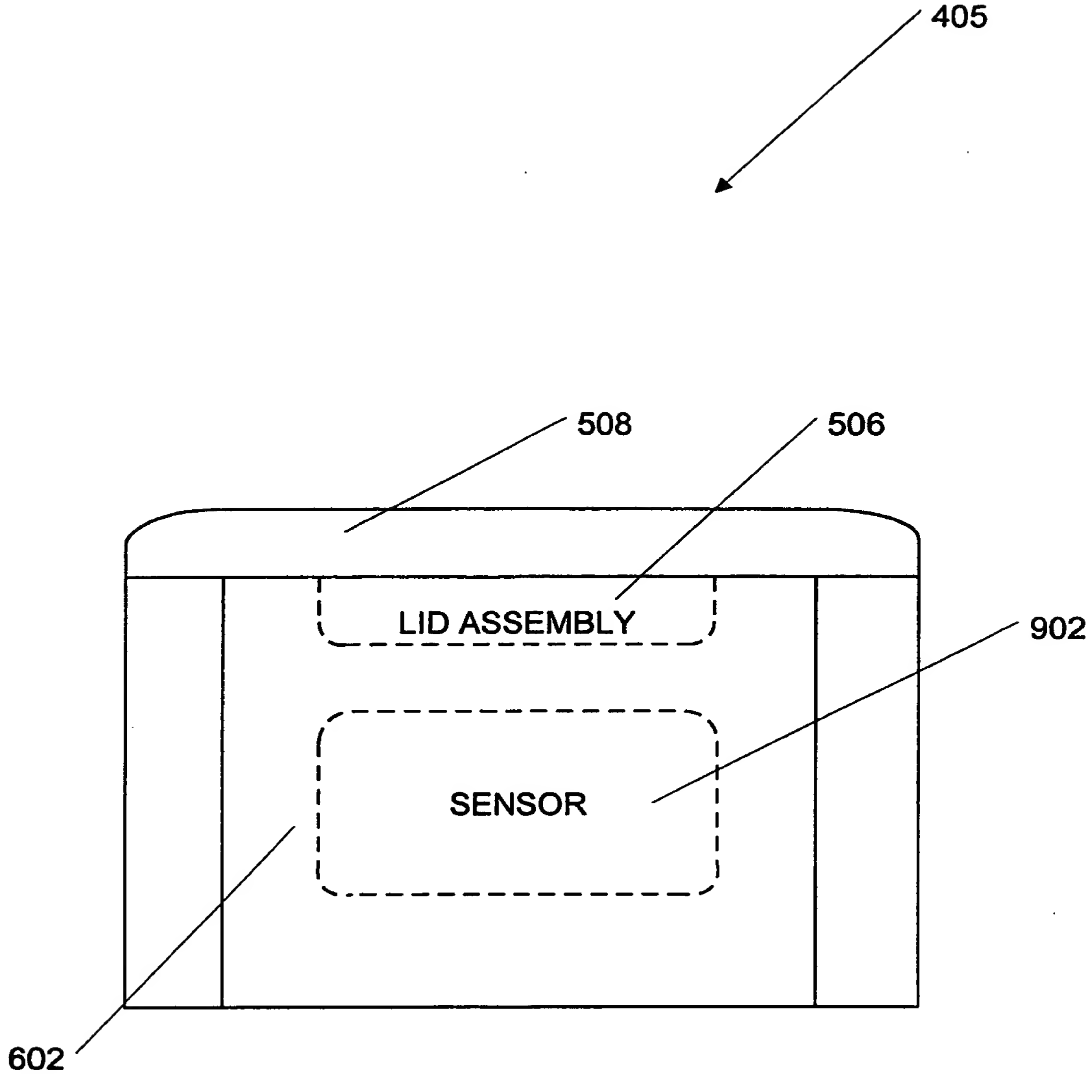

FIGURE 10A

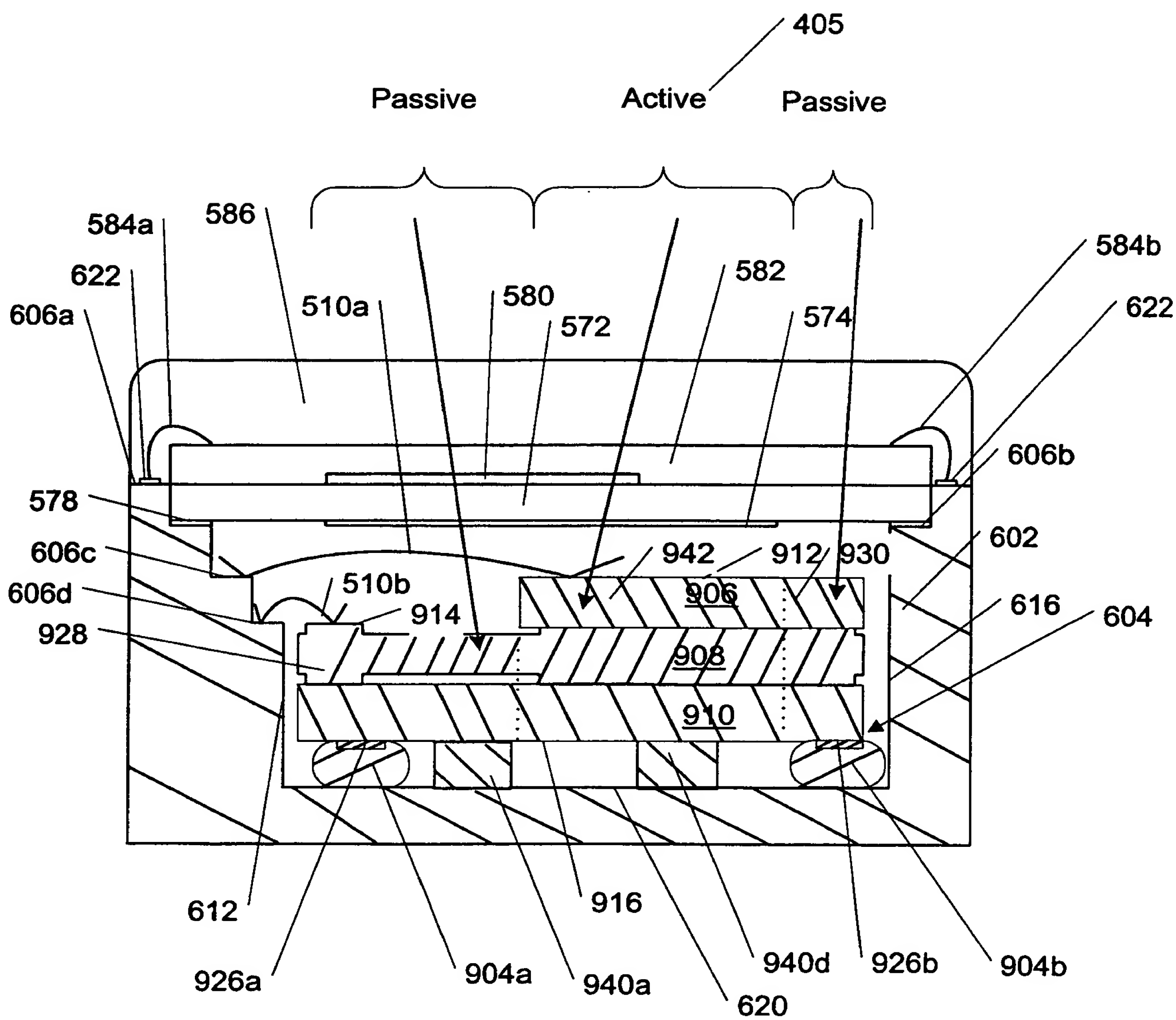
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FIGURE 10B

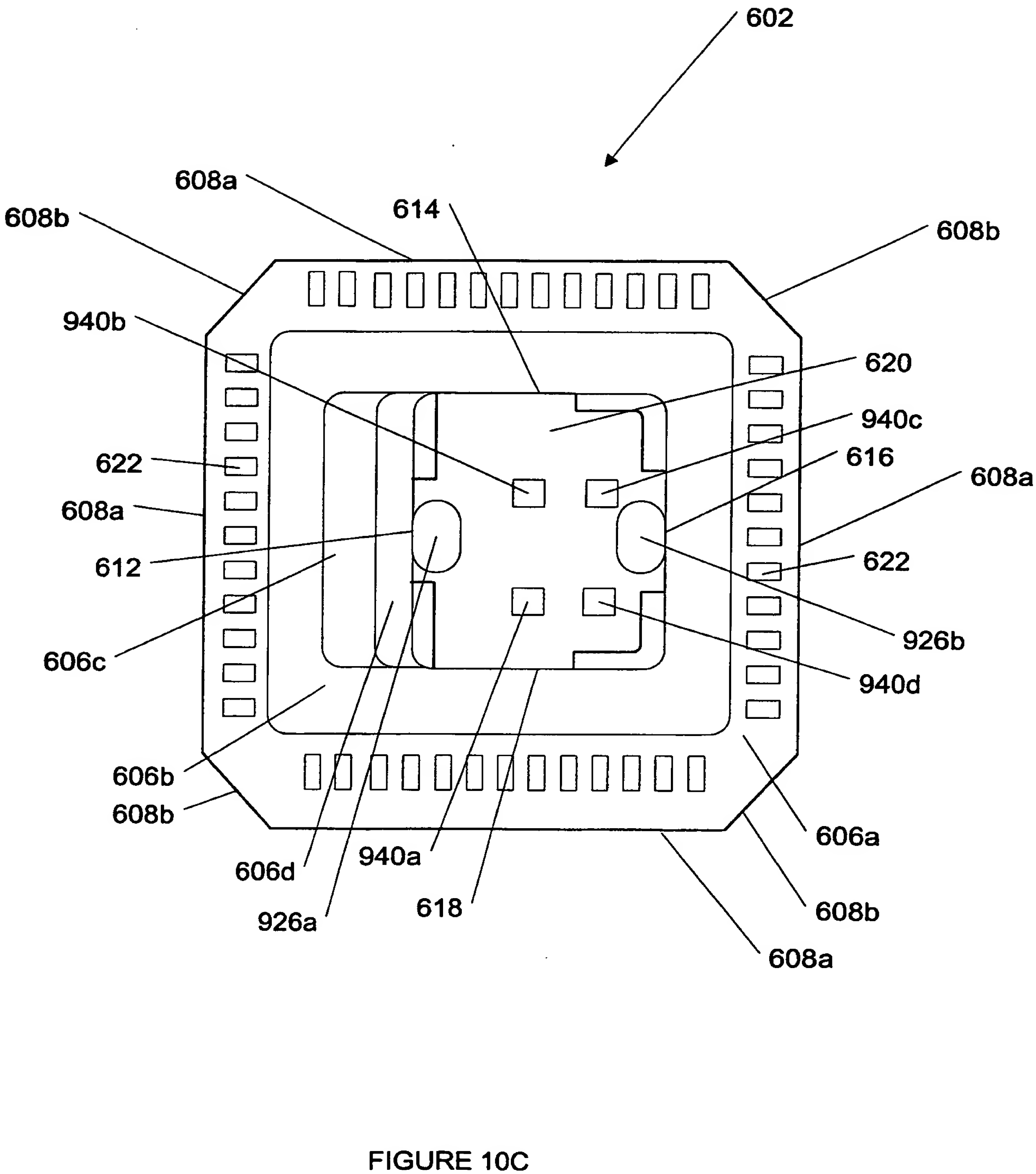
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FIGURE 10C

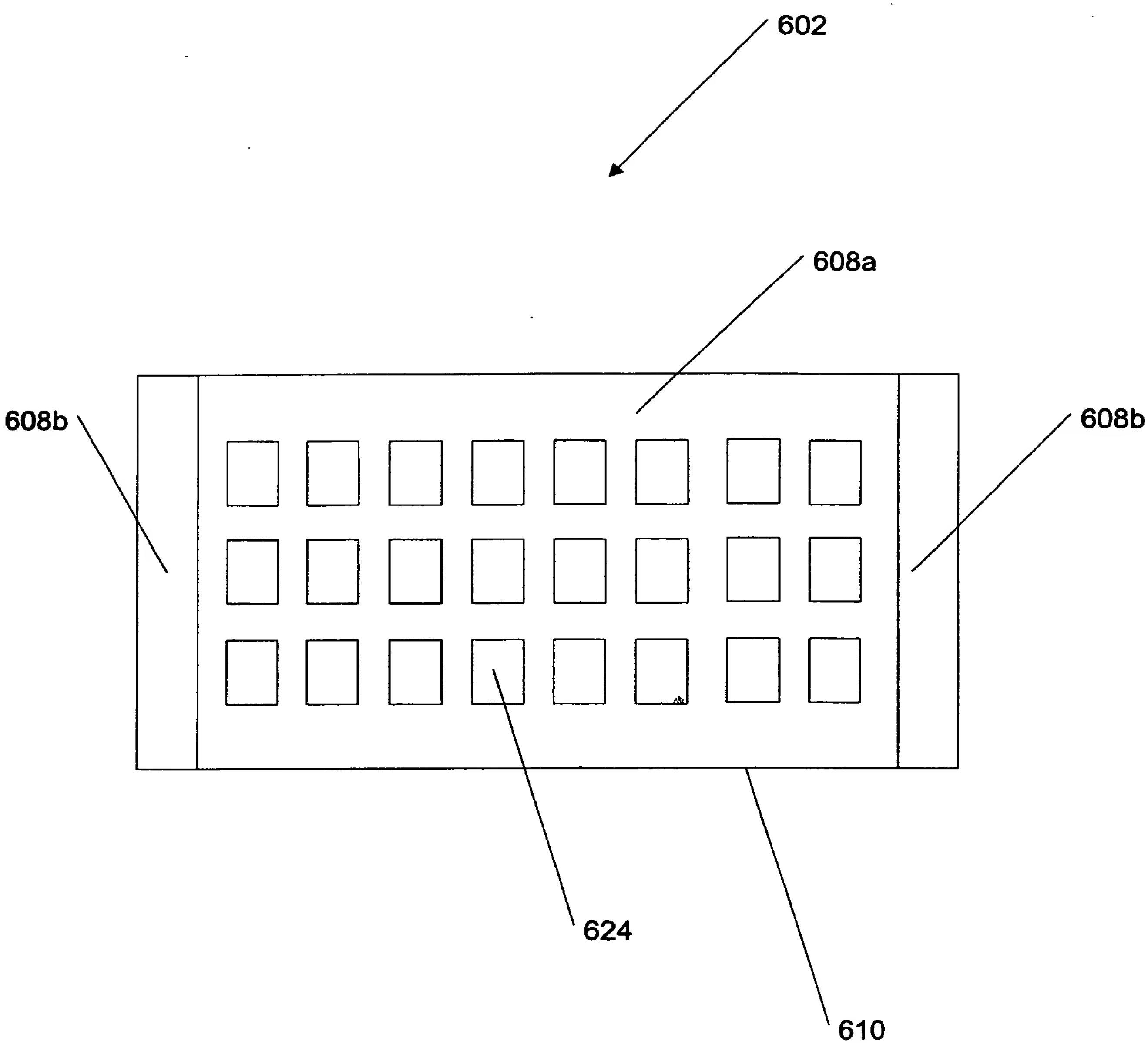

FIGURE 10D

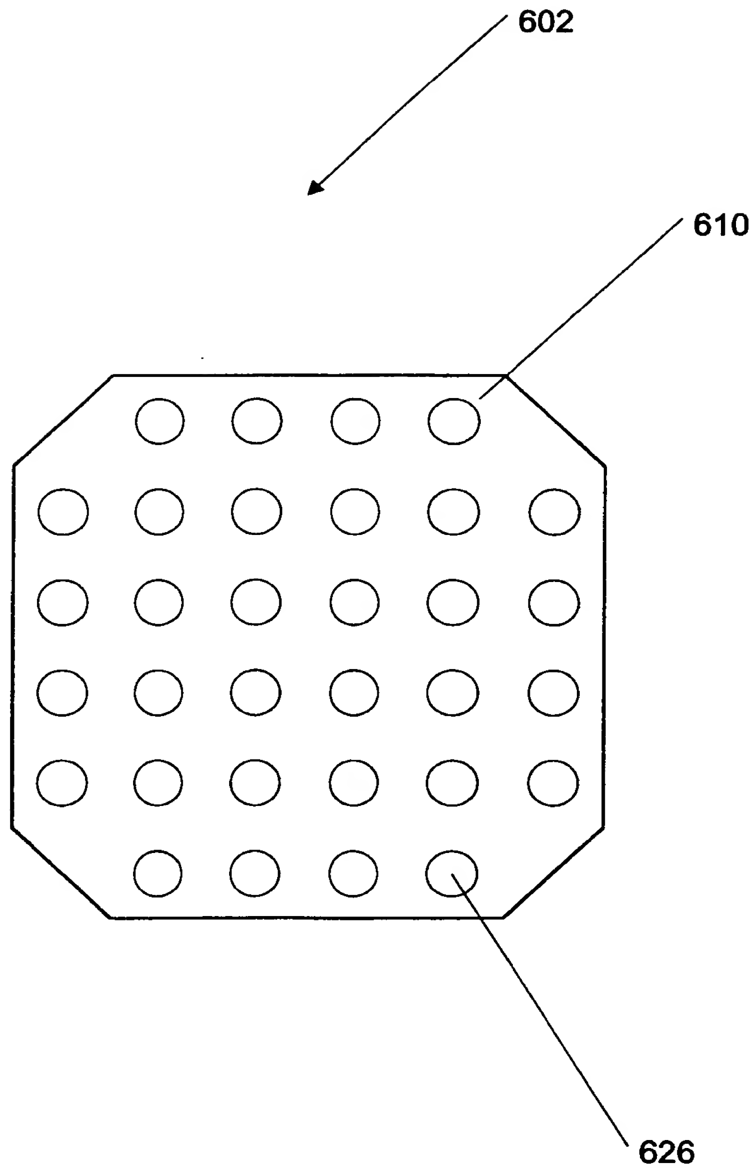

FIGURE 10E

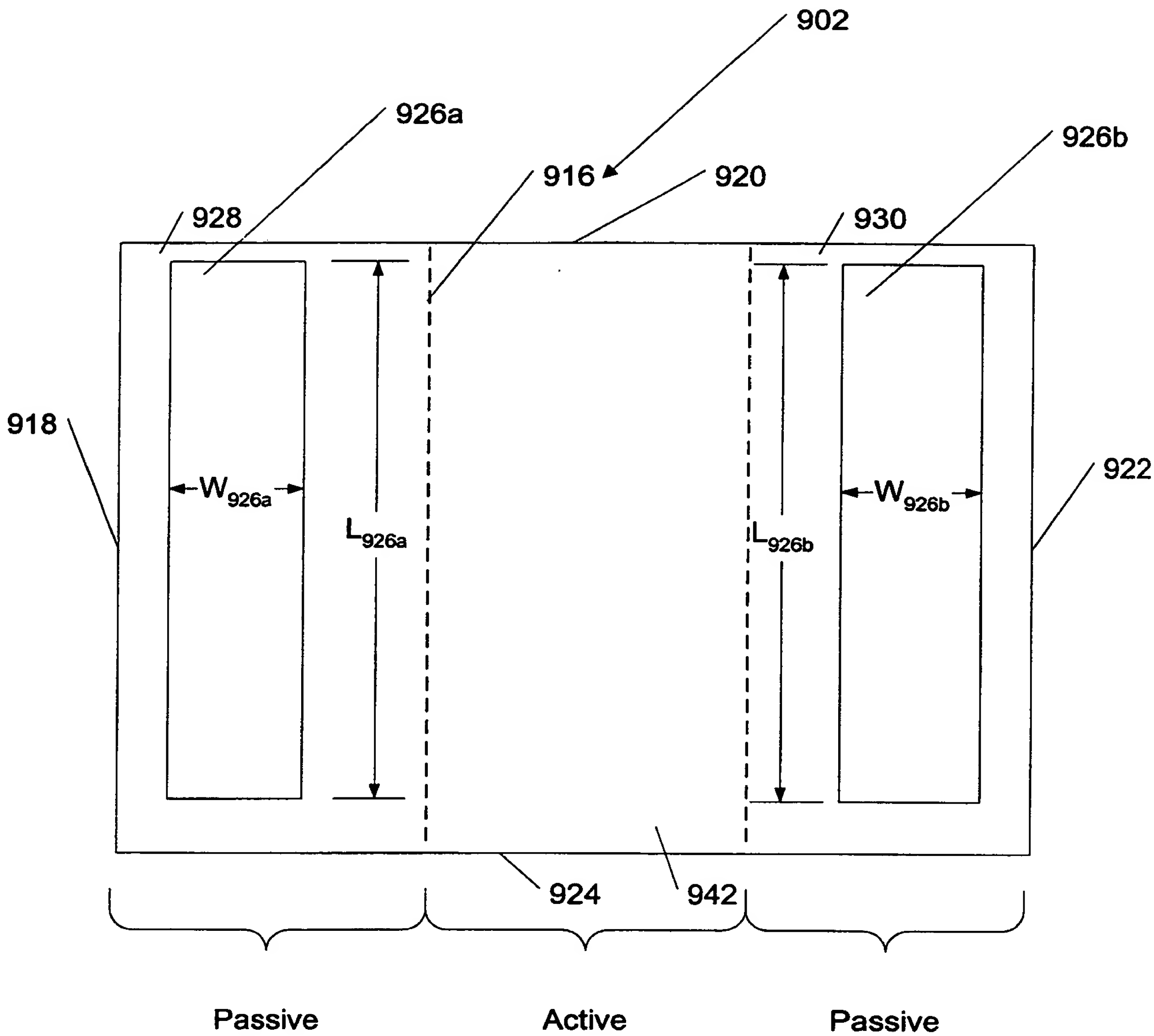
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FIGURE 10F

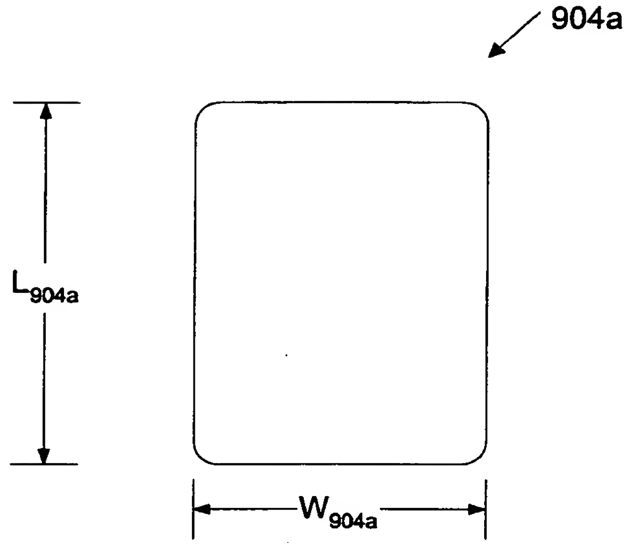

FIGURE 10G

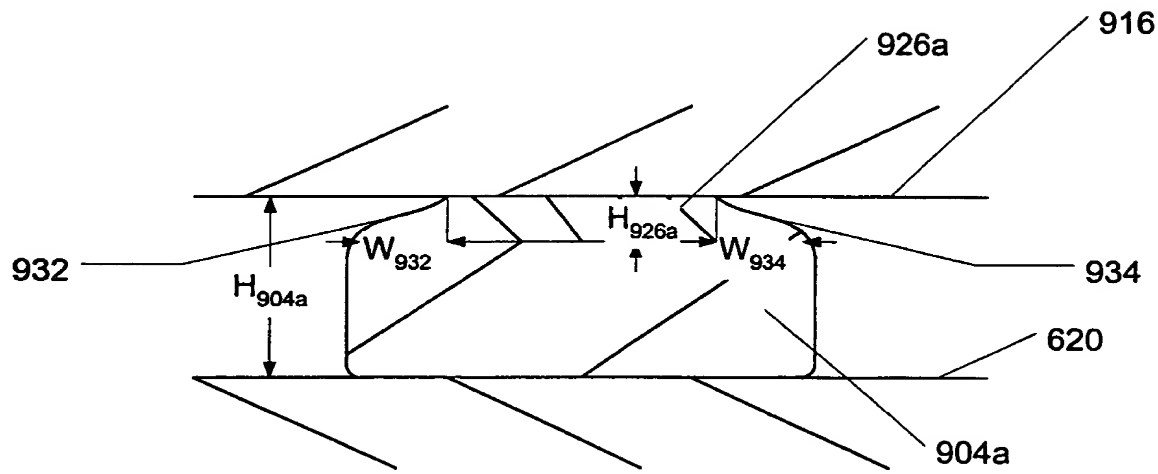

FIGURE 10H

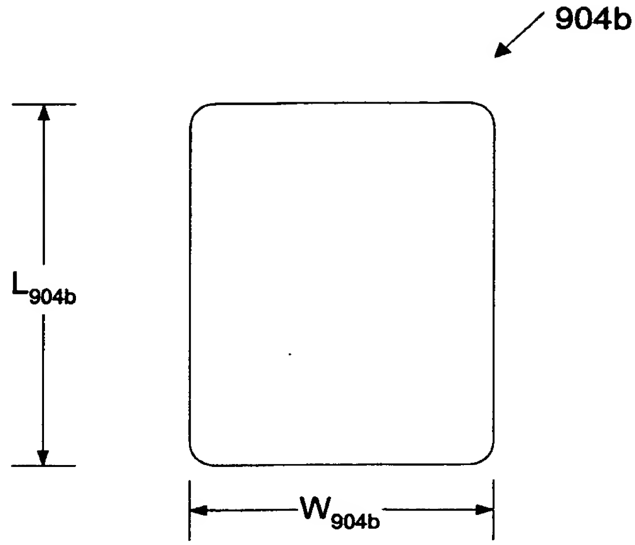

FIGURE 10I

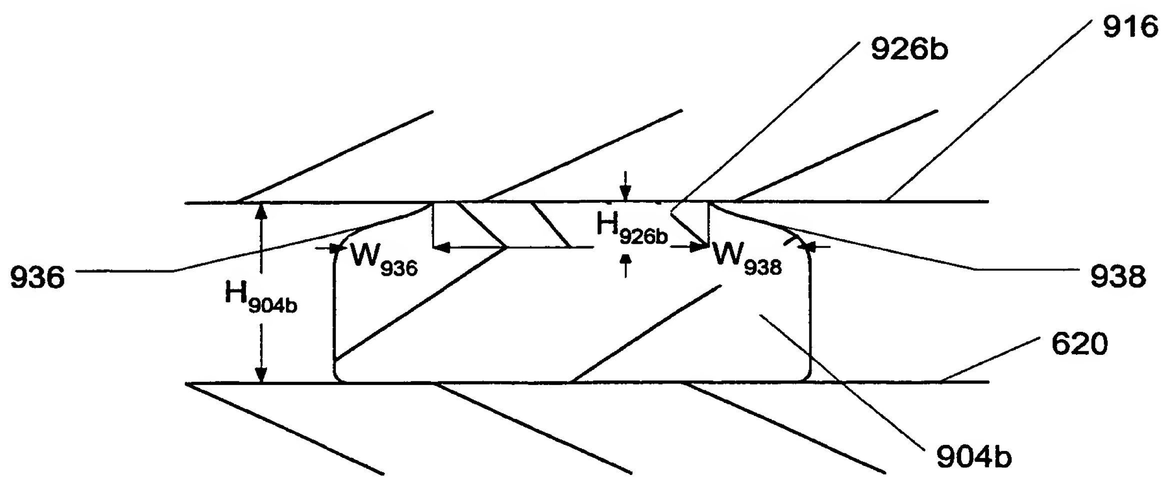

FIGURE 10J

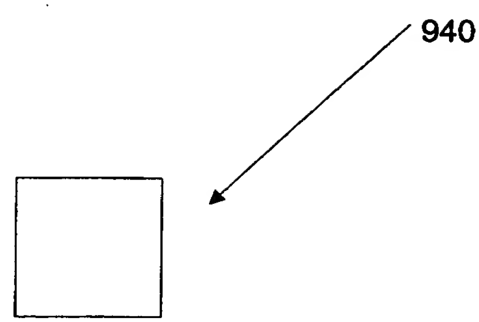

FIGURE 10K

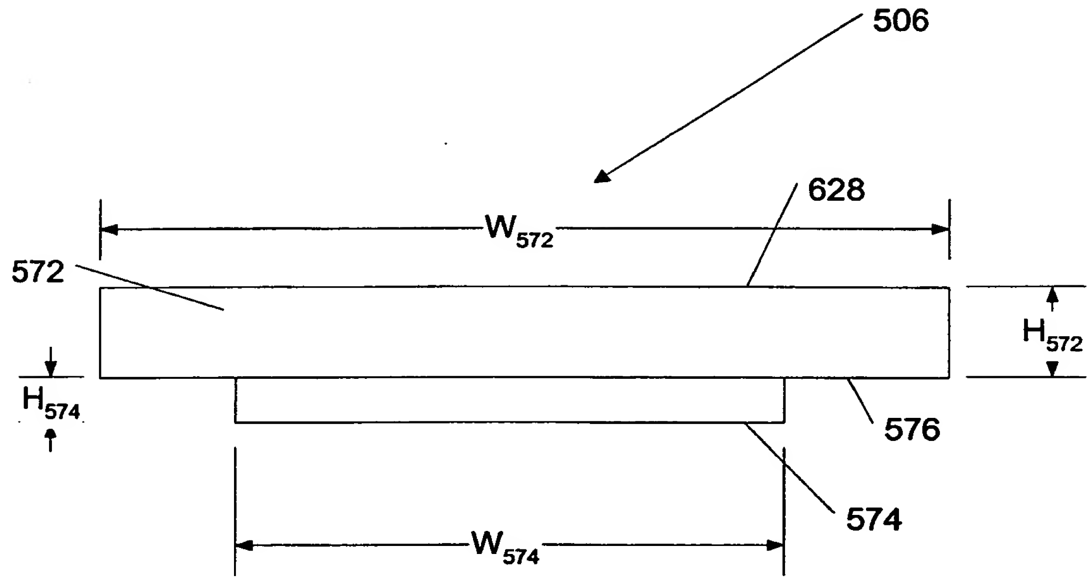

FIGURE 10L

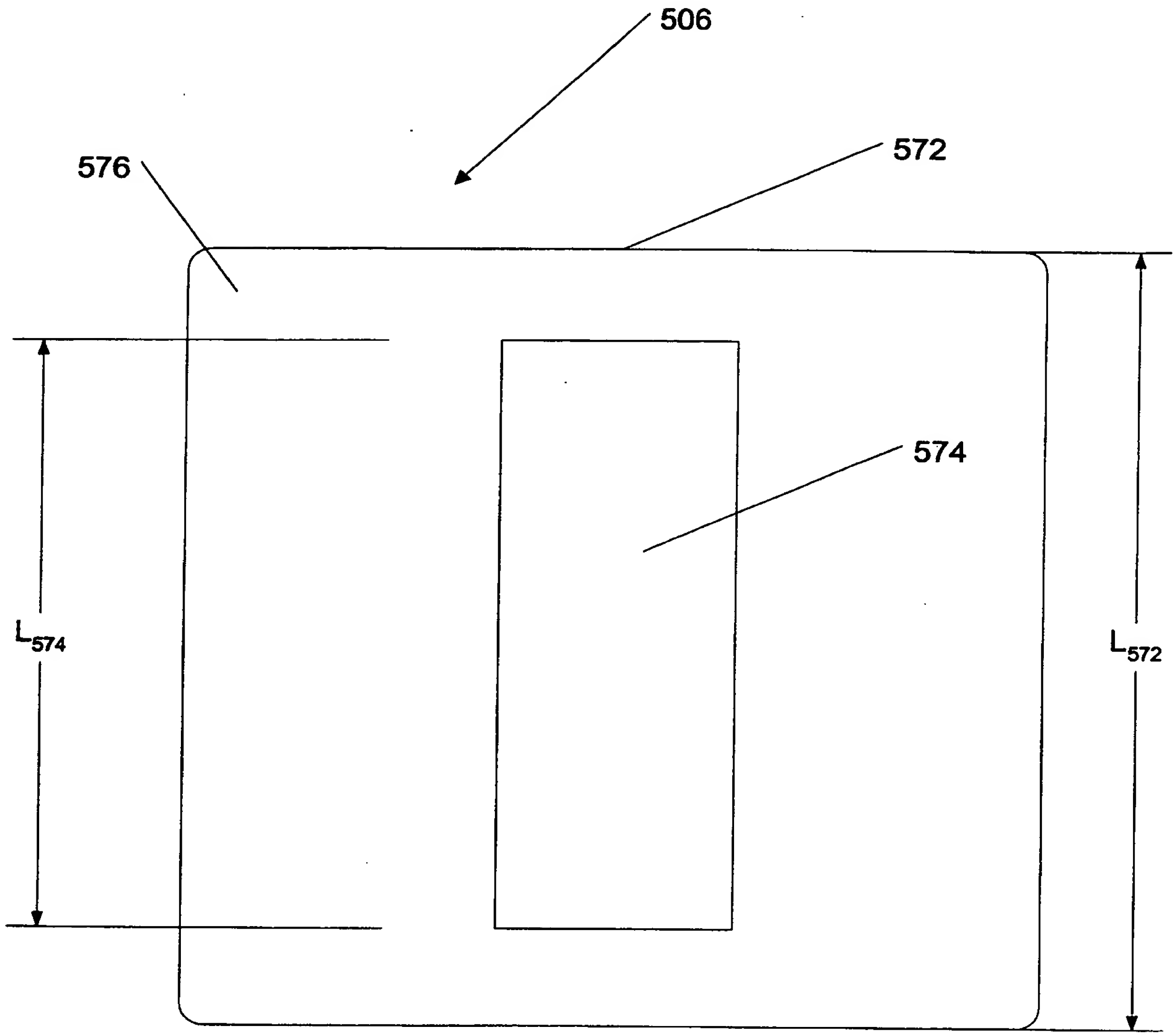

FIGURE 10M

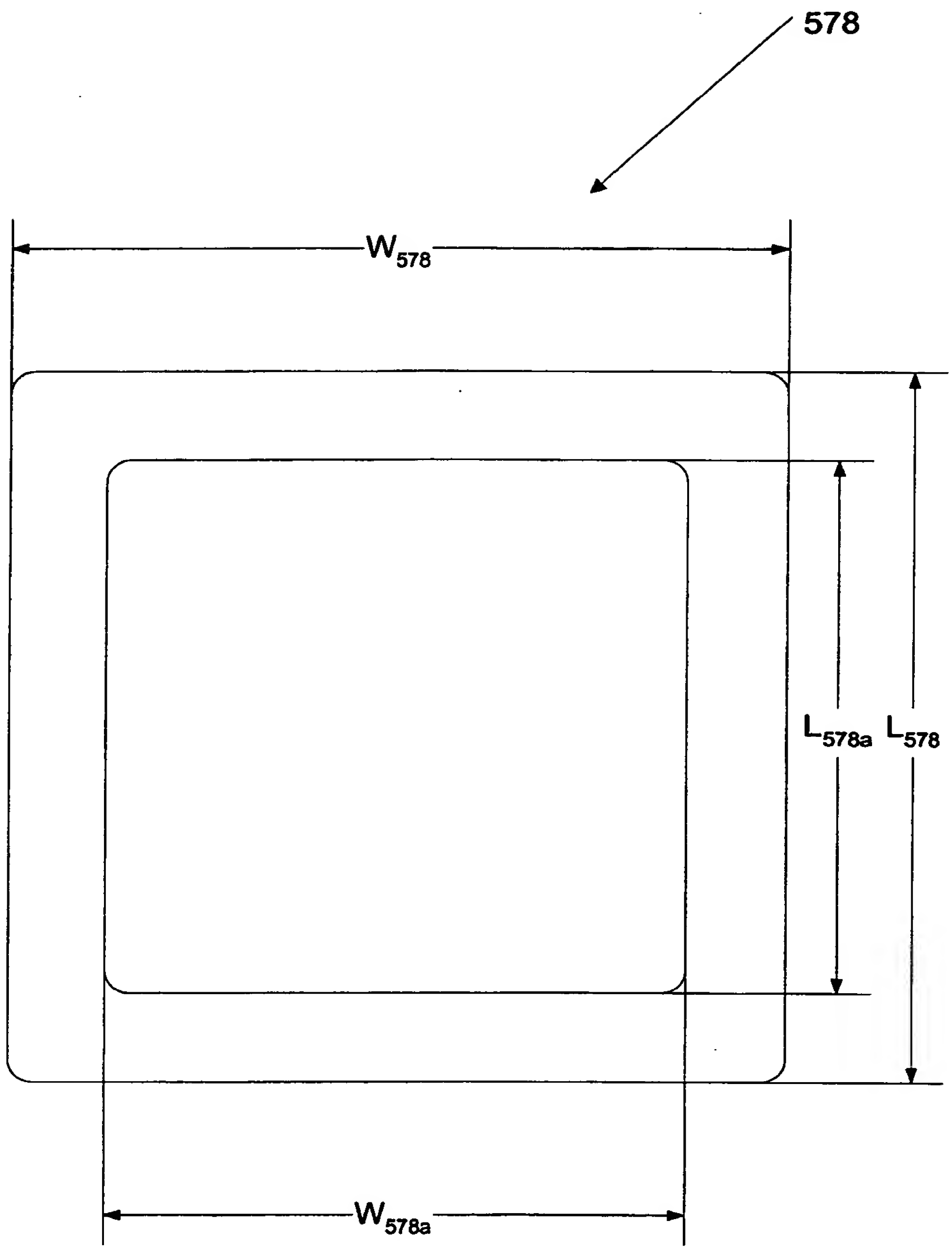

FIGURE 10N

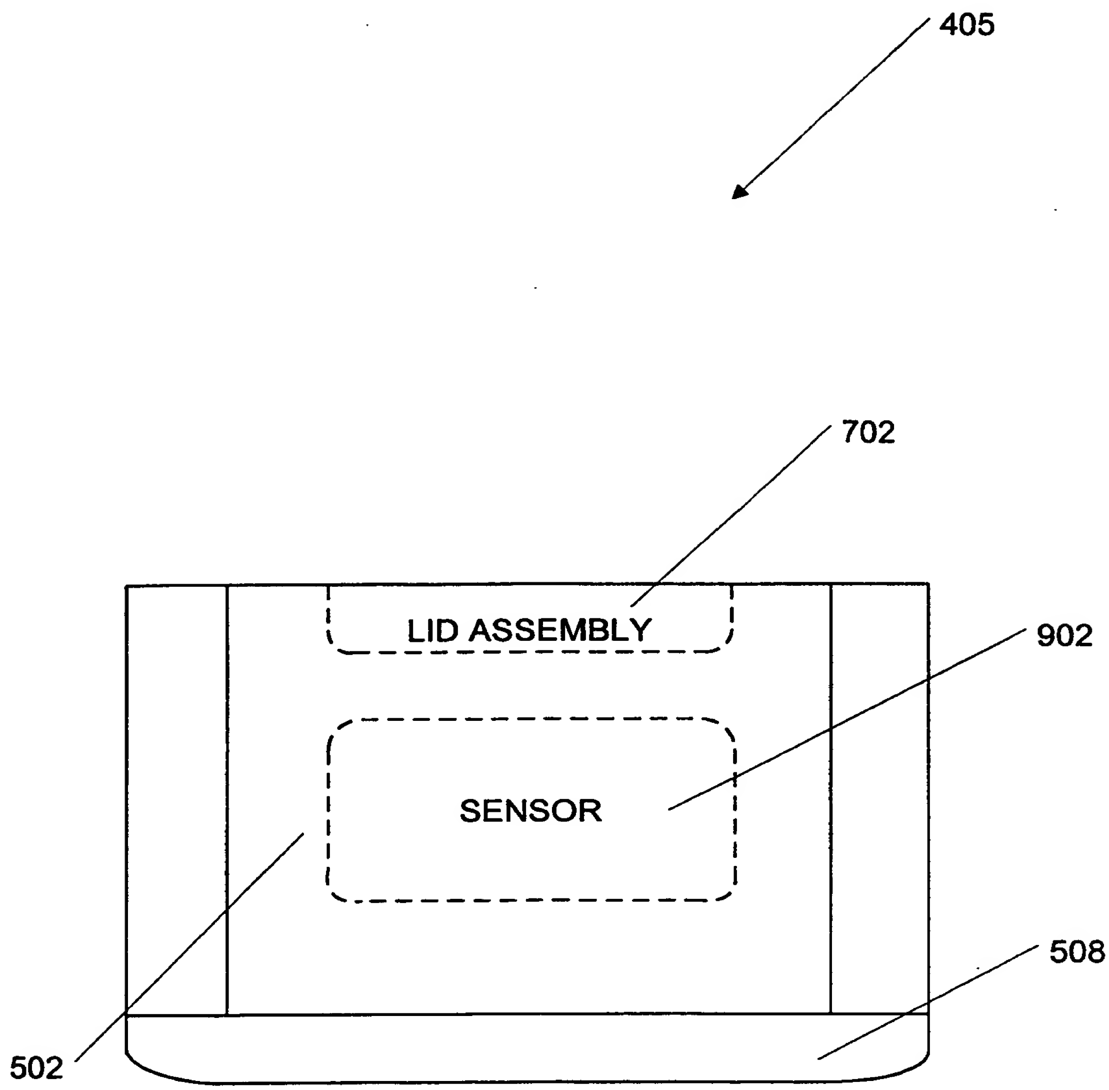

FIGURE 11A

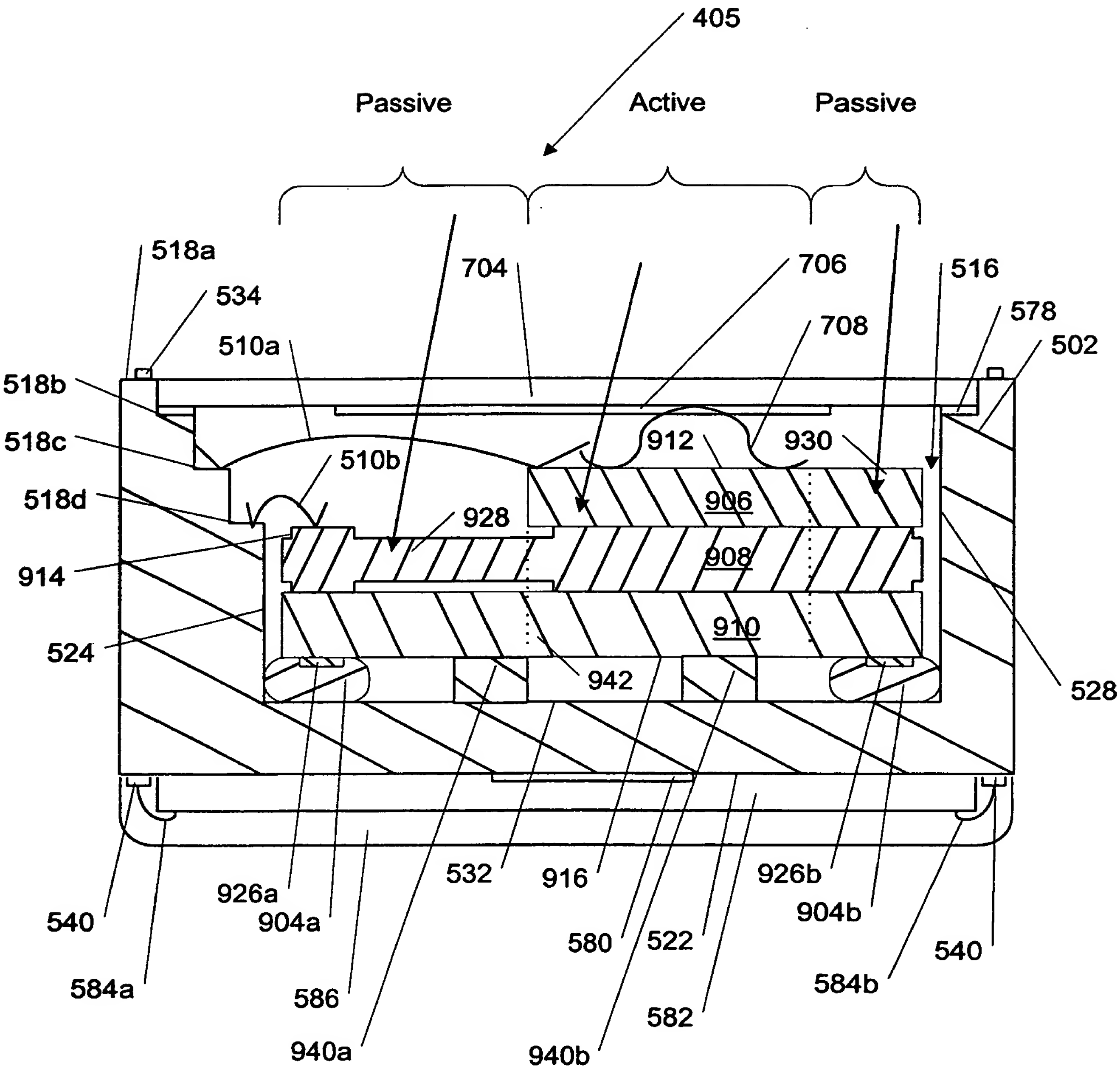
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FIGURE 11B

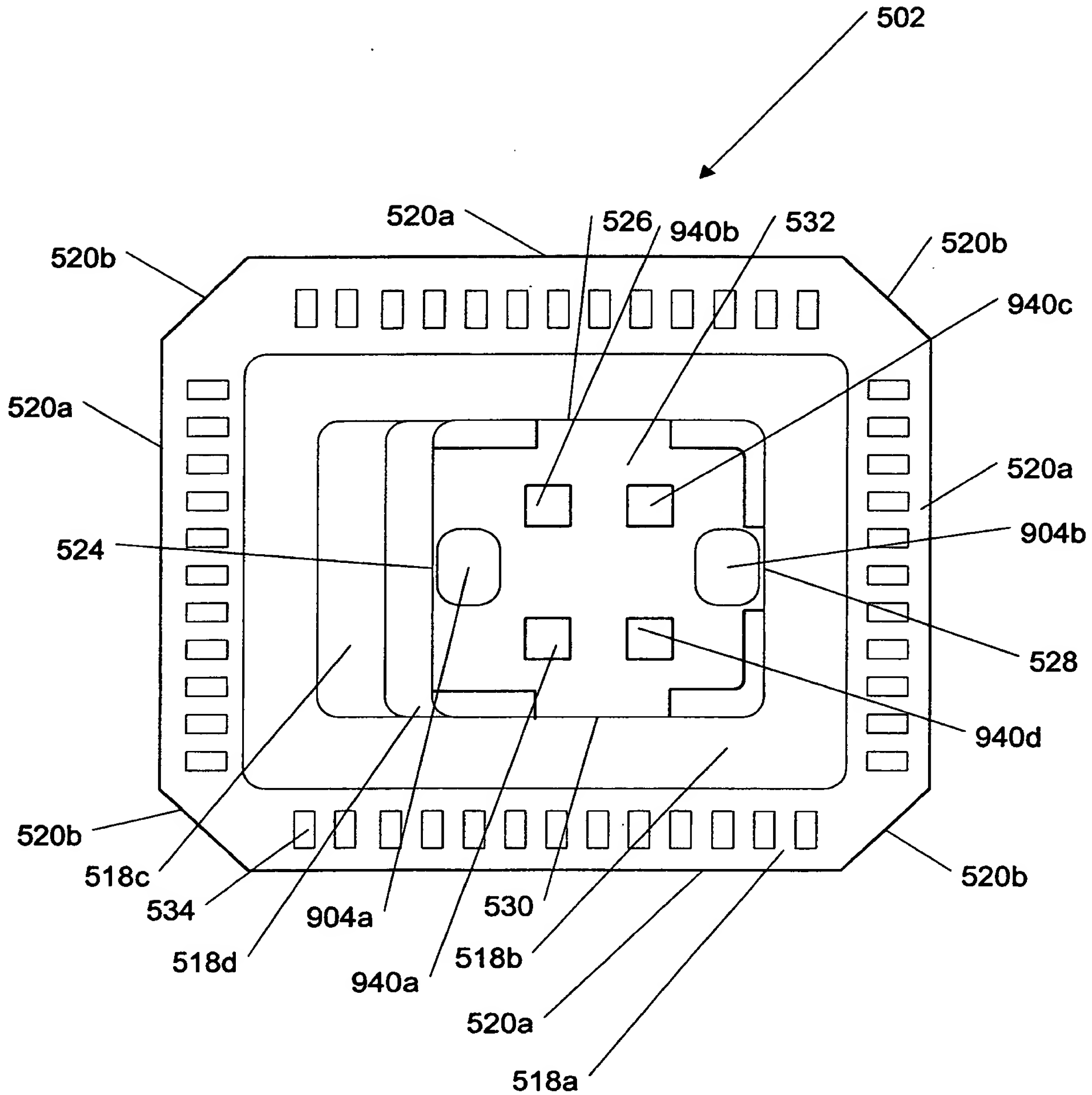
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FIGURE 11C

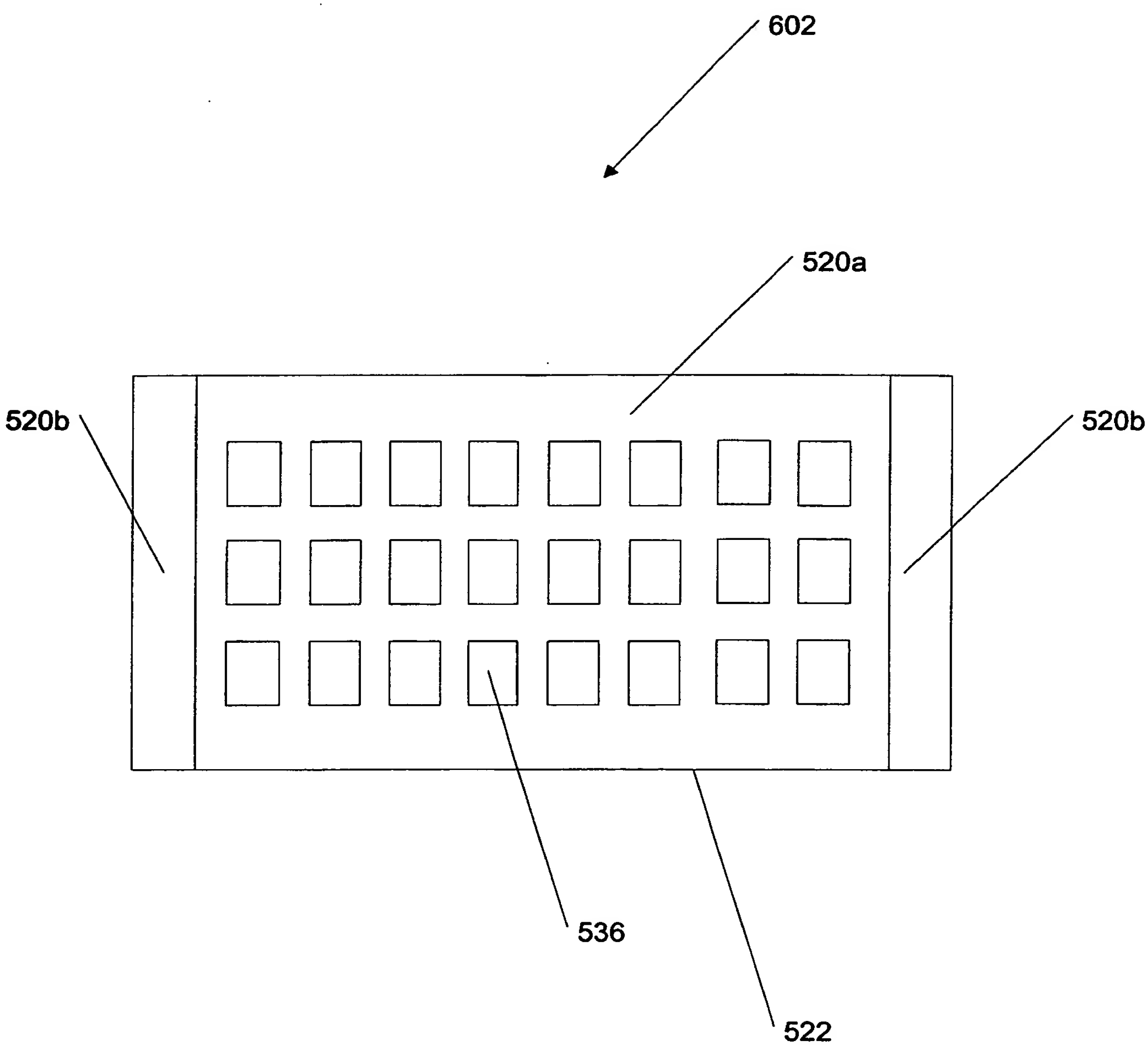

FIGURE 11D

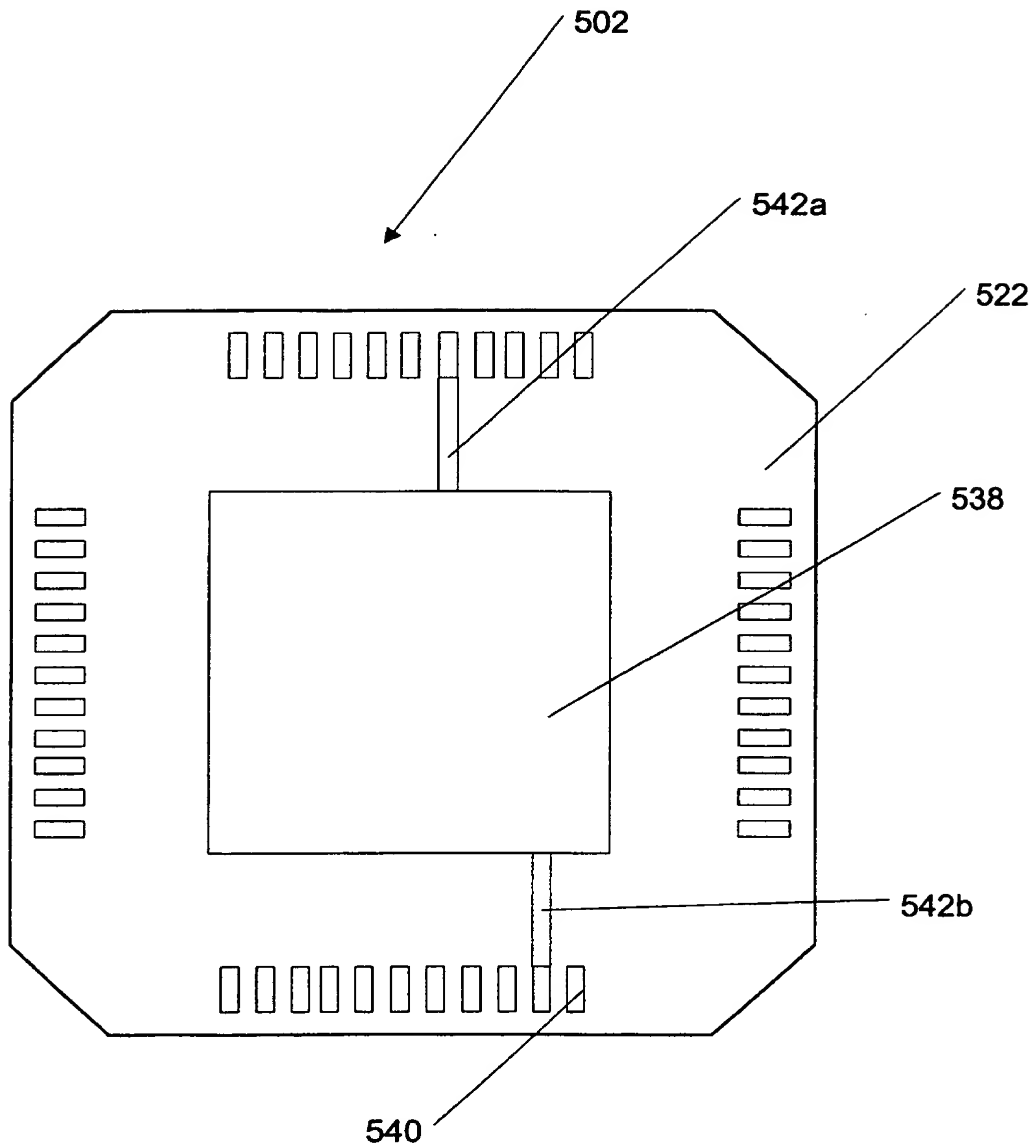

FIGURE 11E

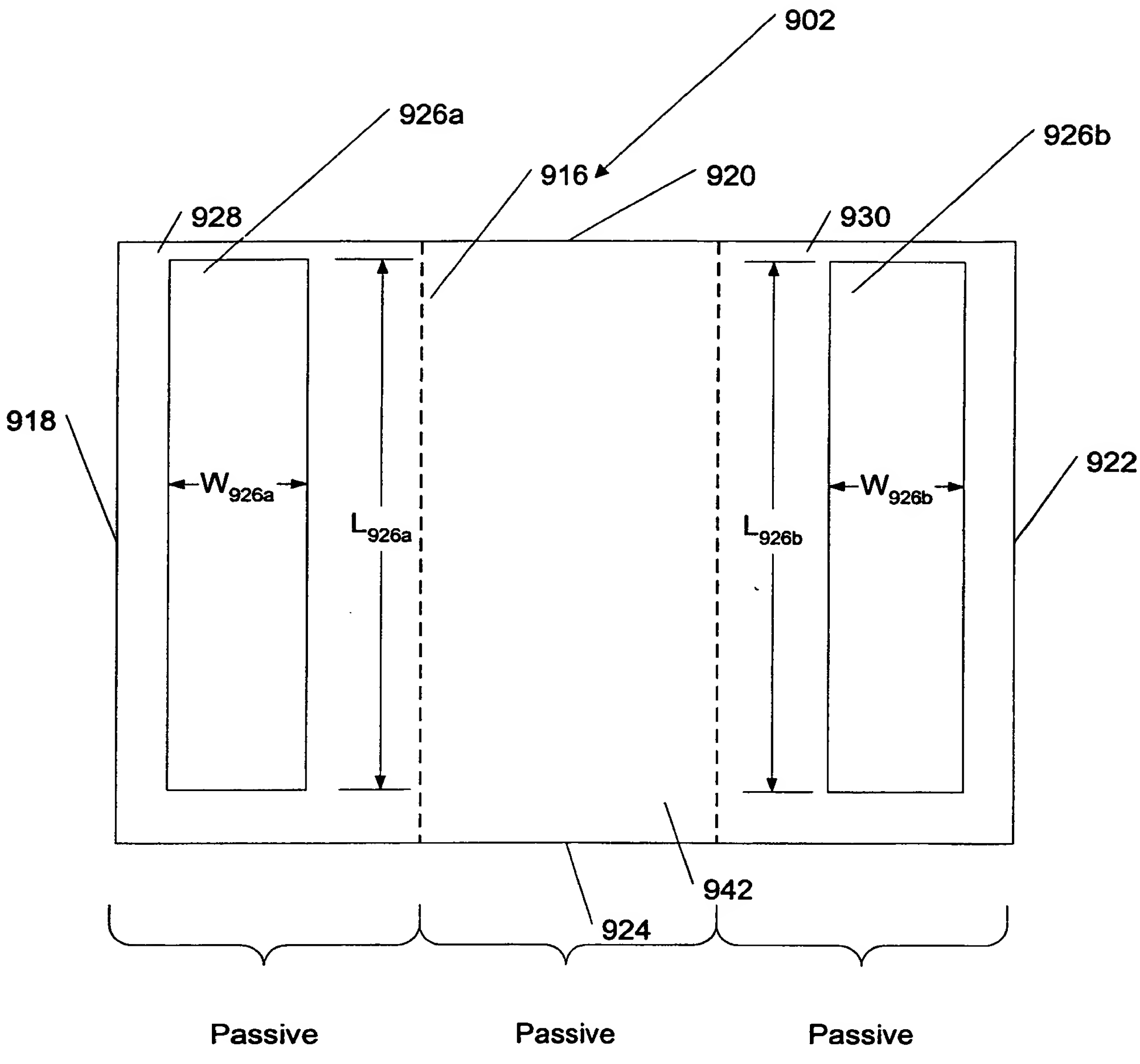
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FIGURE 11F

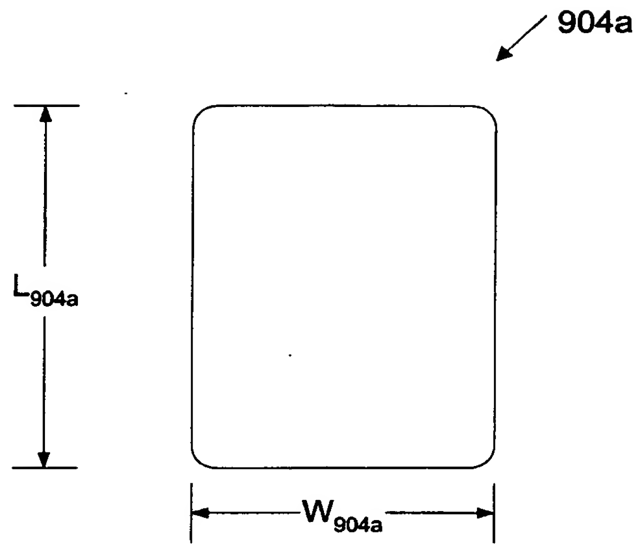

FIGURE 11G

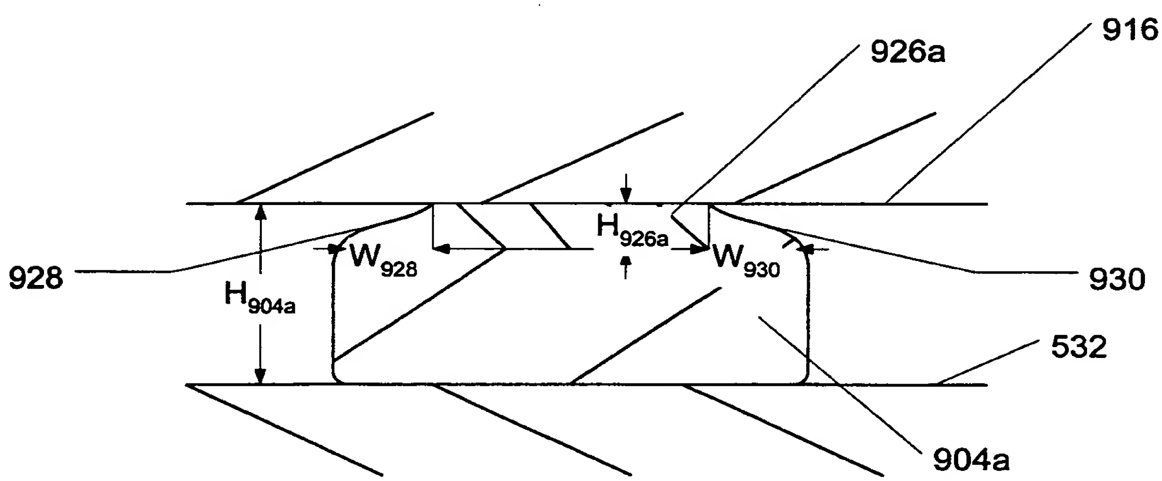

FIGURE 11H

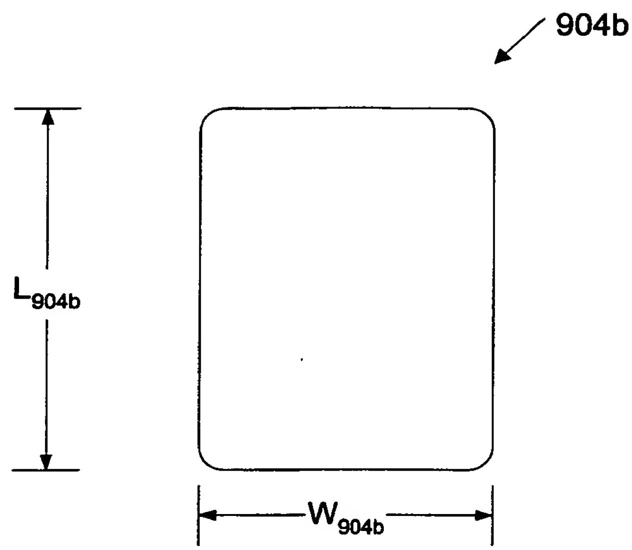

FIGURE 11I

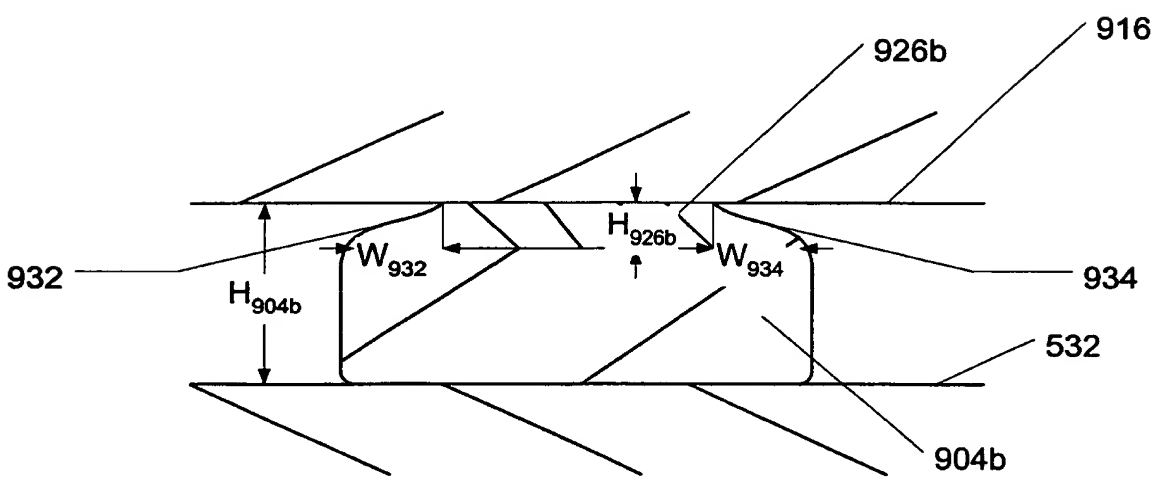

FIGURE 11J

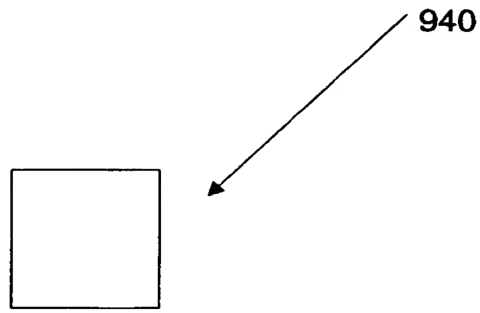

FIGURE 11K

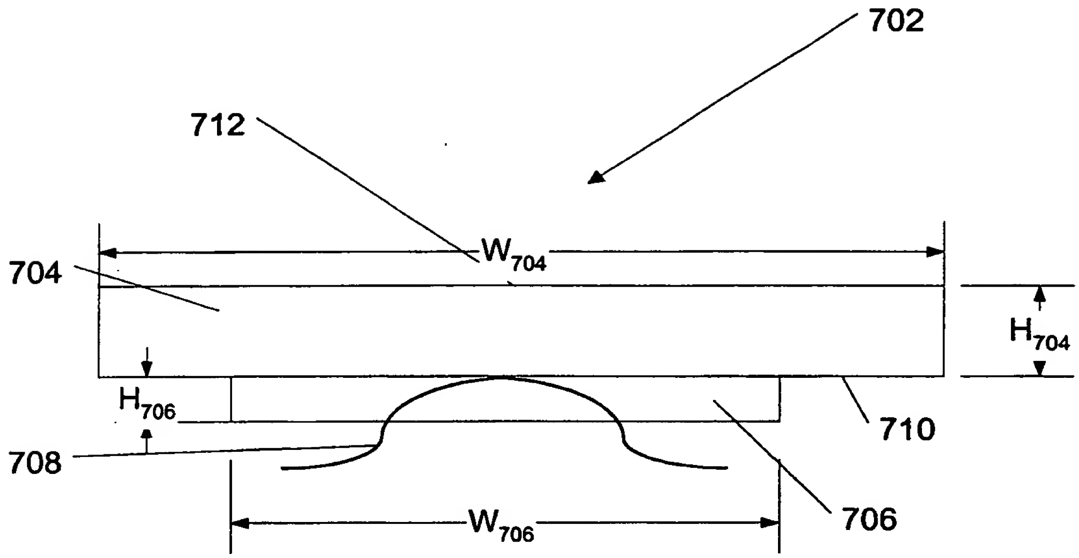

FIGURE 11L

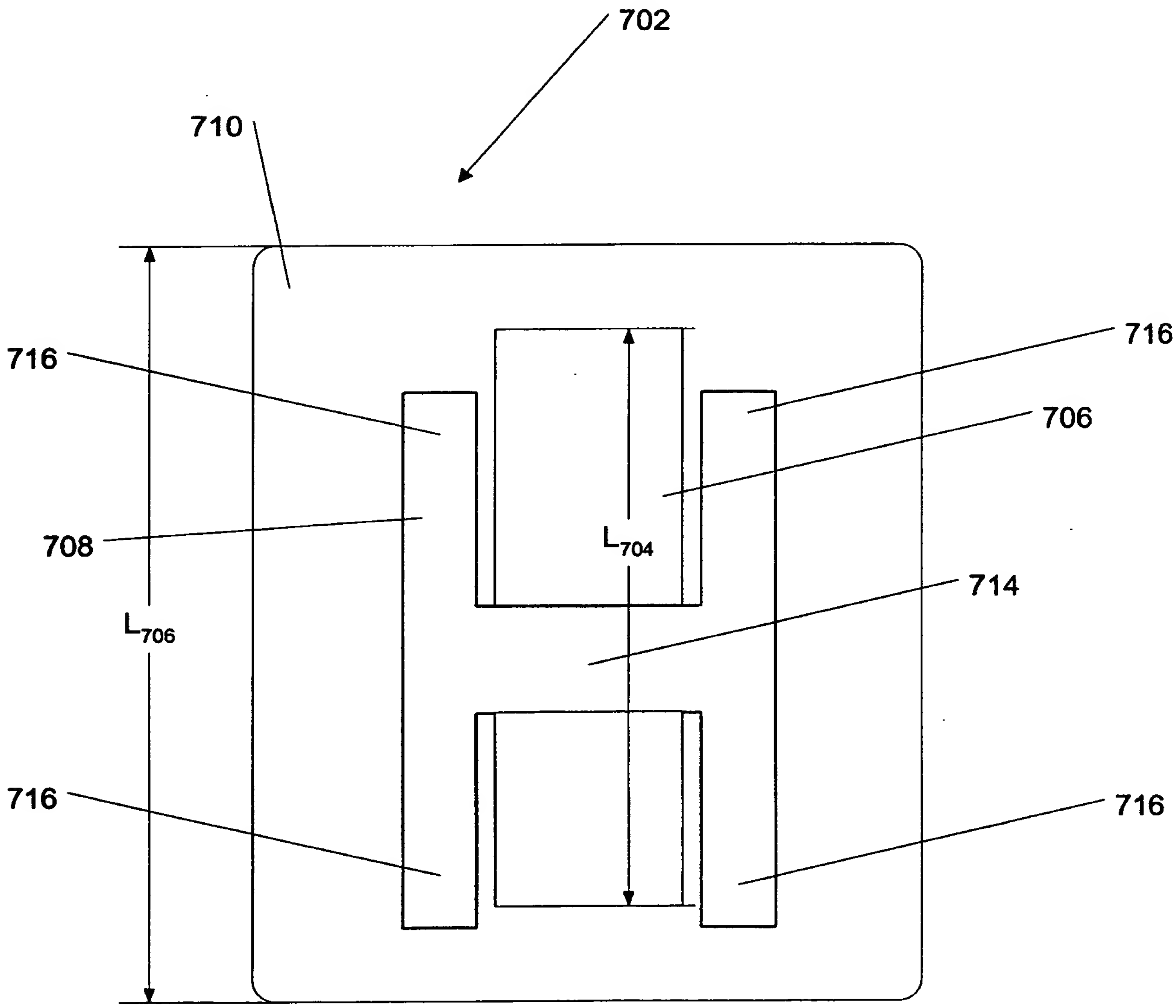

FIGURE 11M

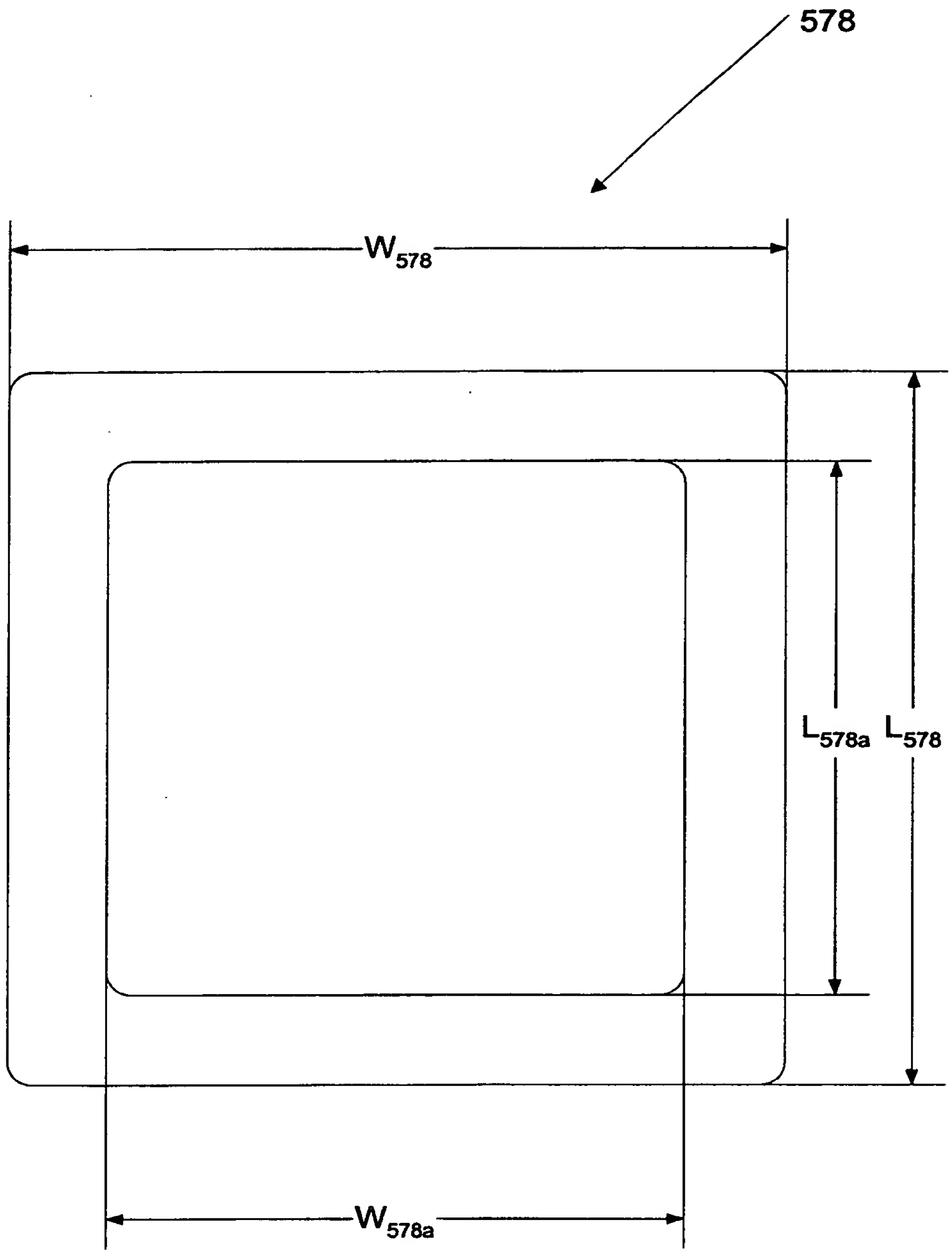

FIGURE 11N

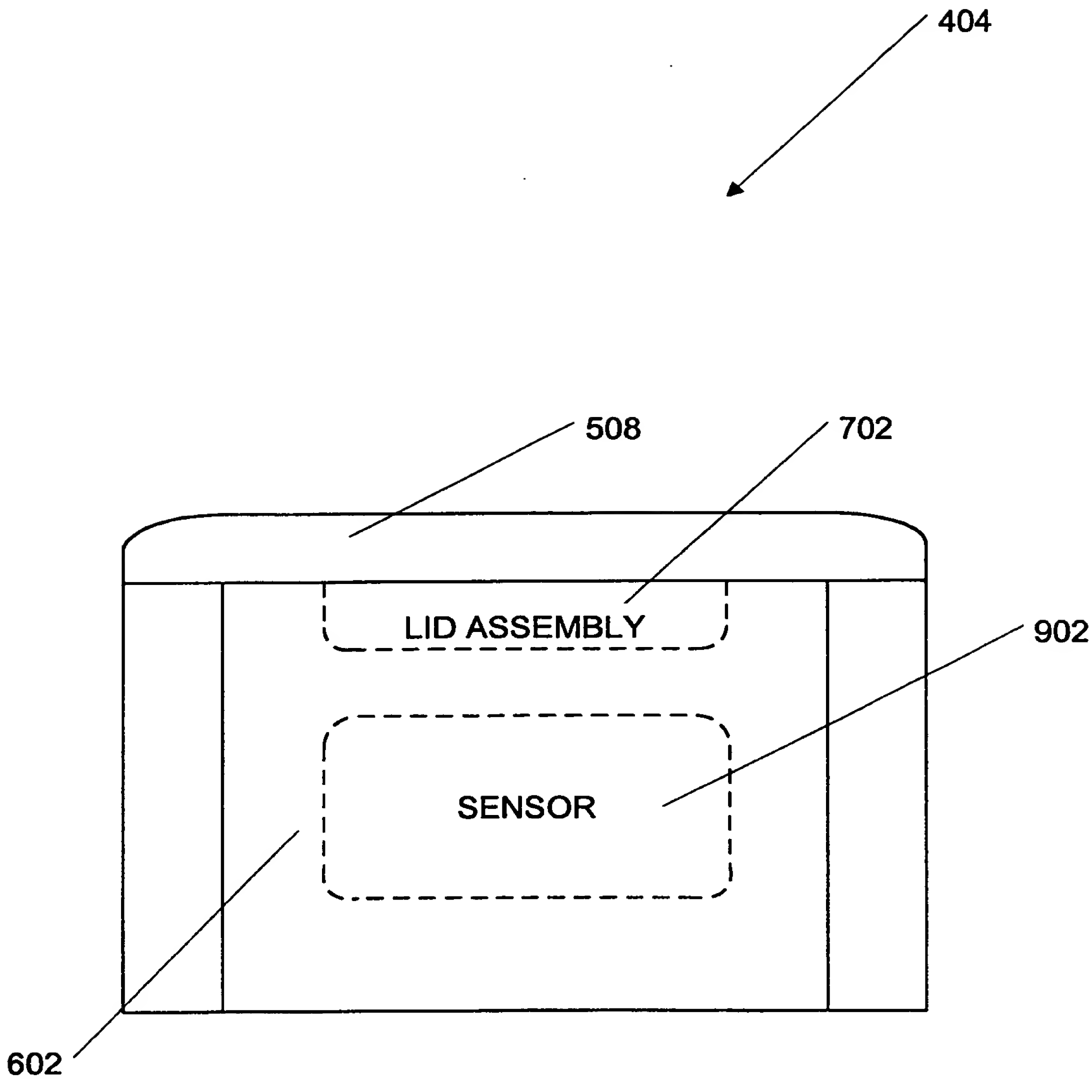

FIGURE 12A

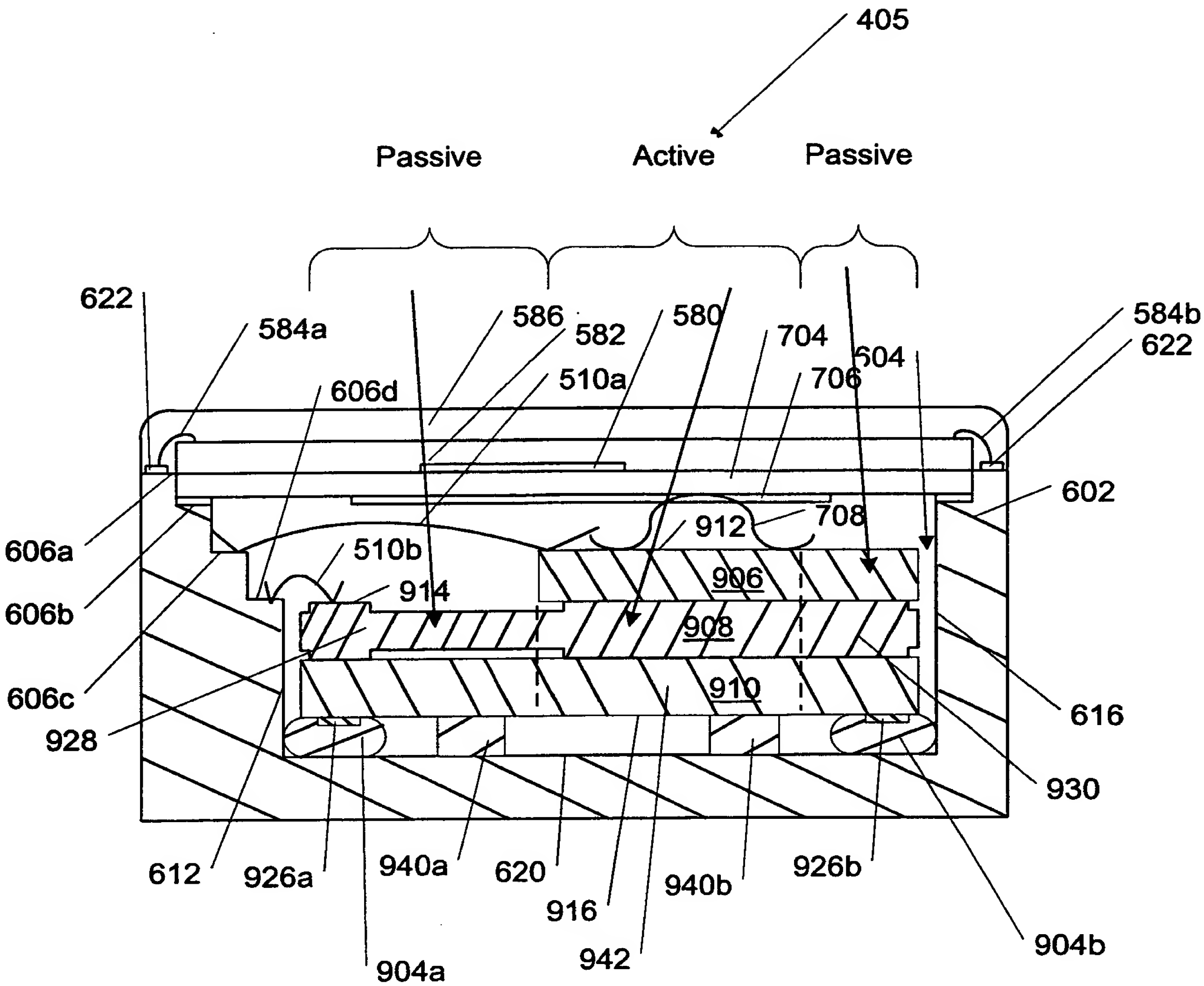
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FIGURE 12B

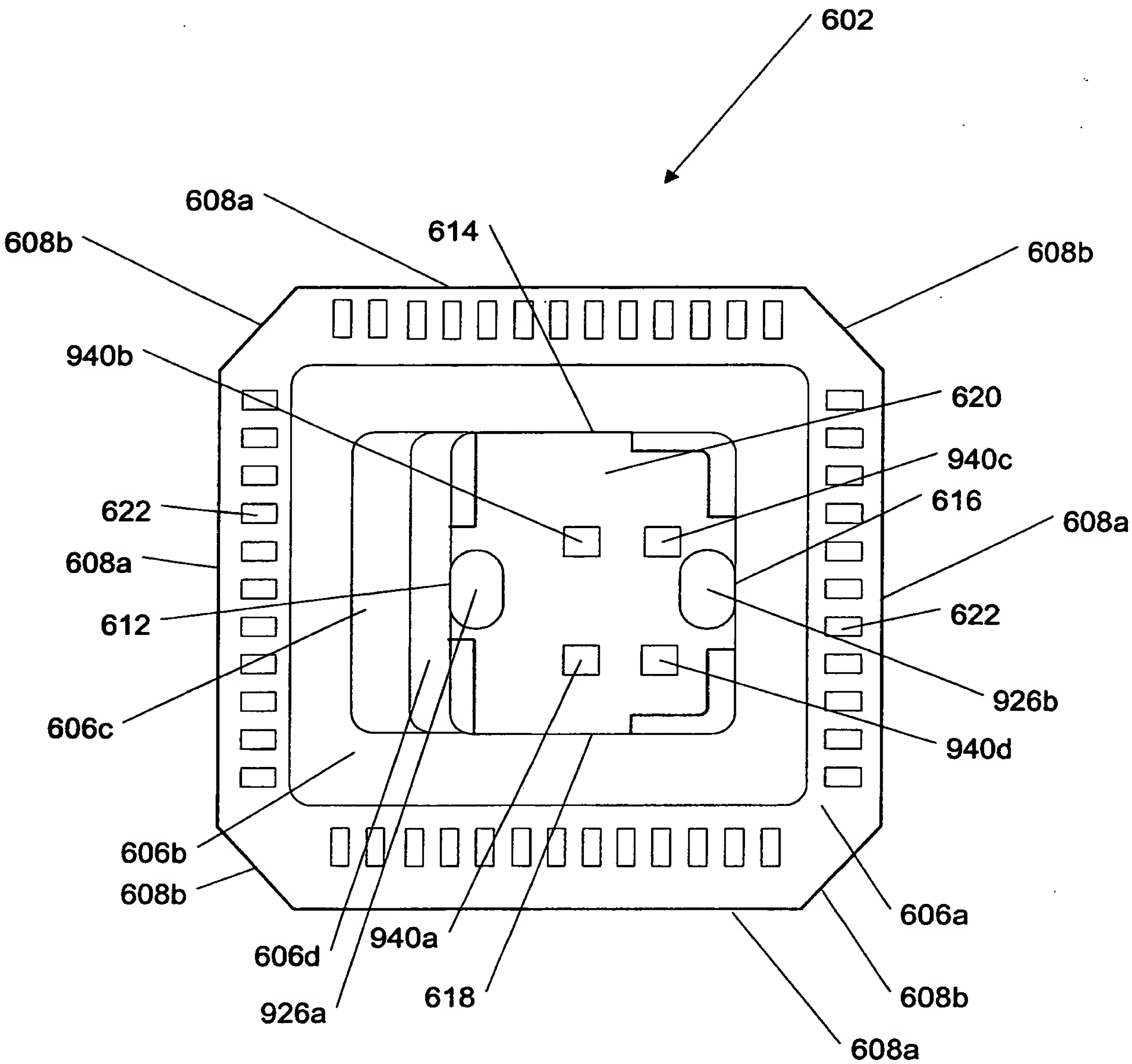
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FIGURE 12C

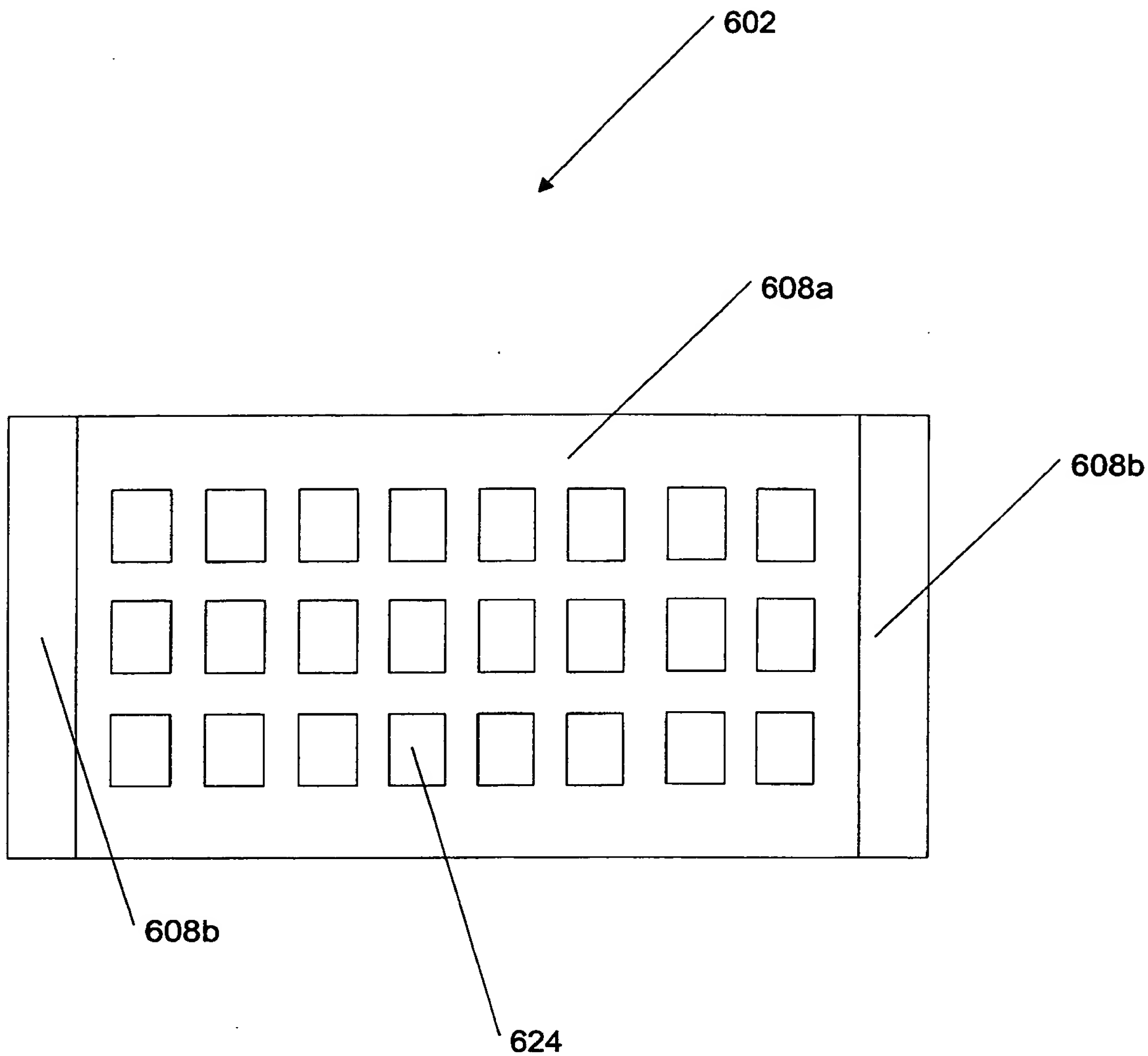

FIGURE 12D

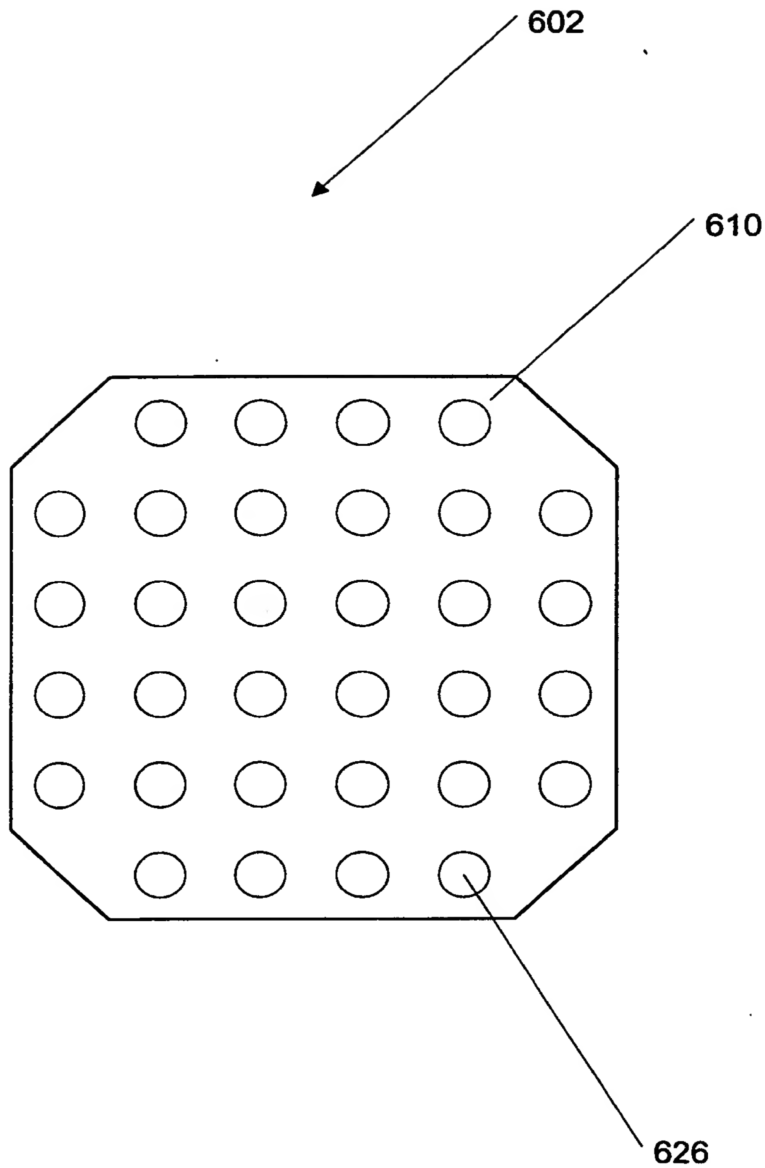

FIGURE 12E

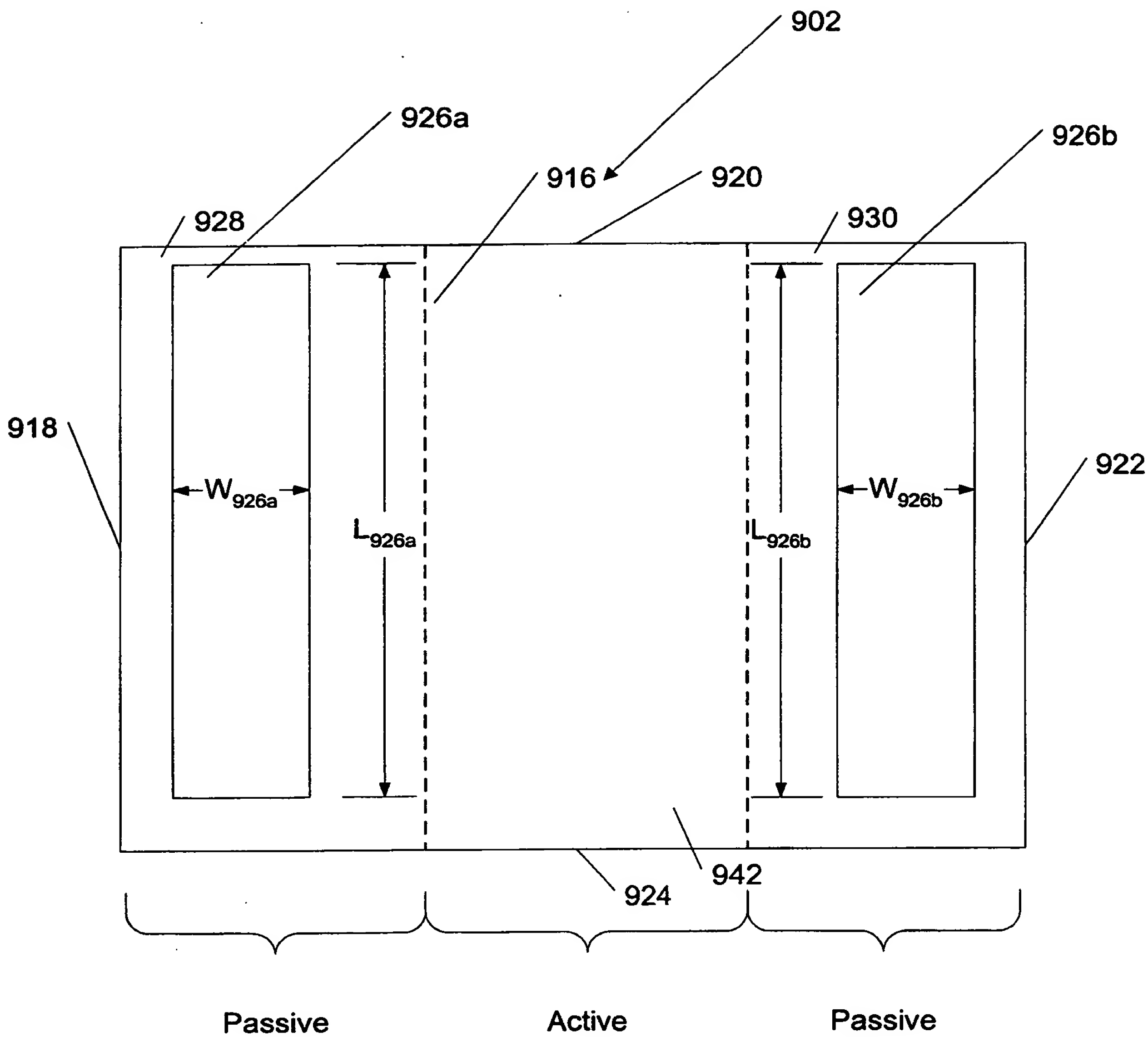
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FIGURE 12F

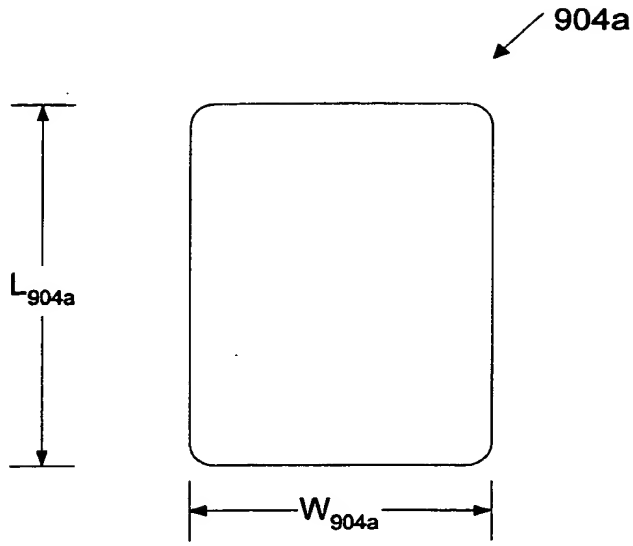

FIGURE 12G

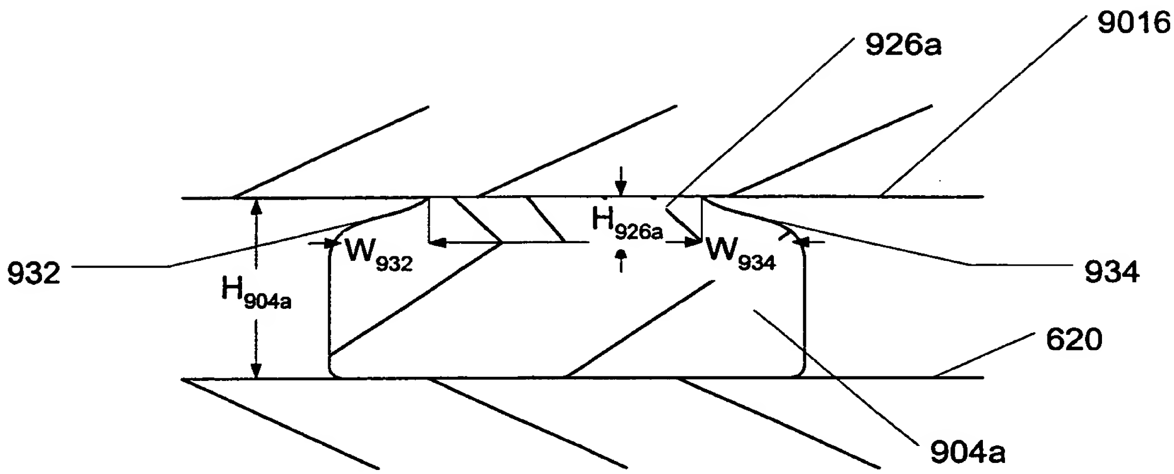

FIGURE 12H

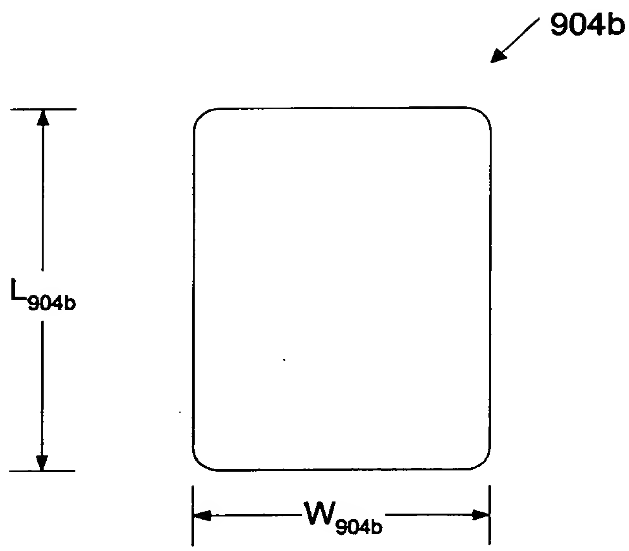

FIGURE 12I

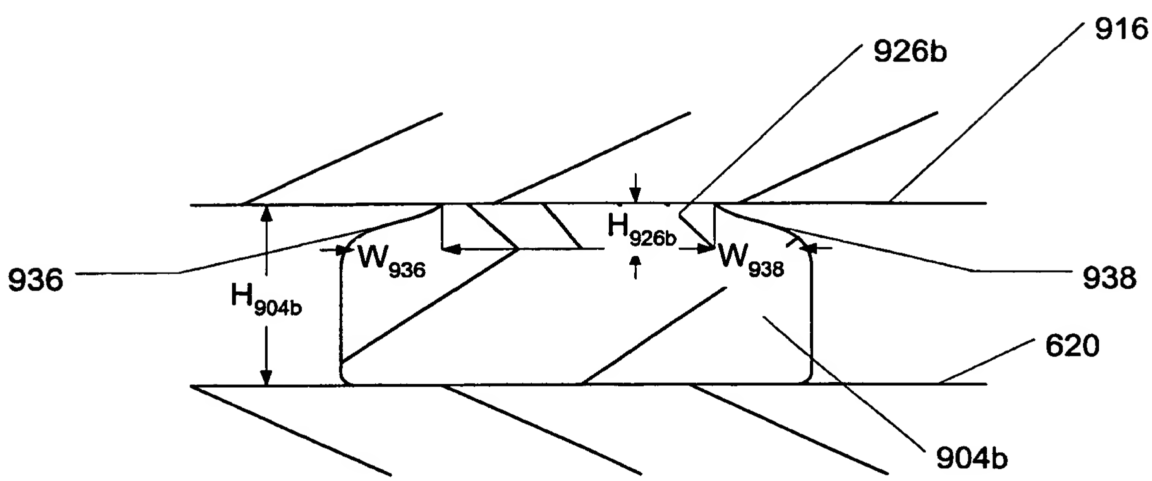

FIGURE 12J

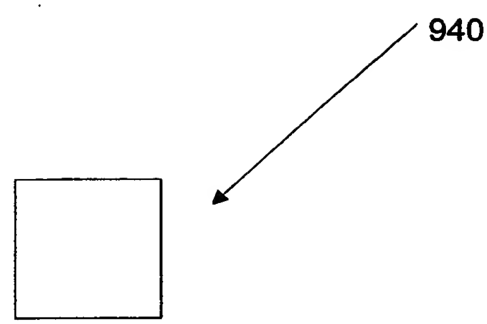

FIGURE 12K

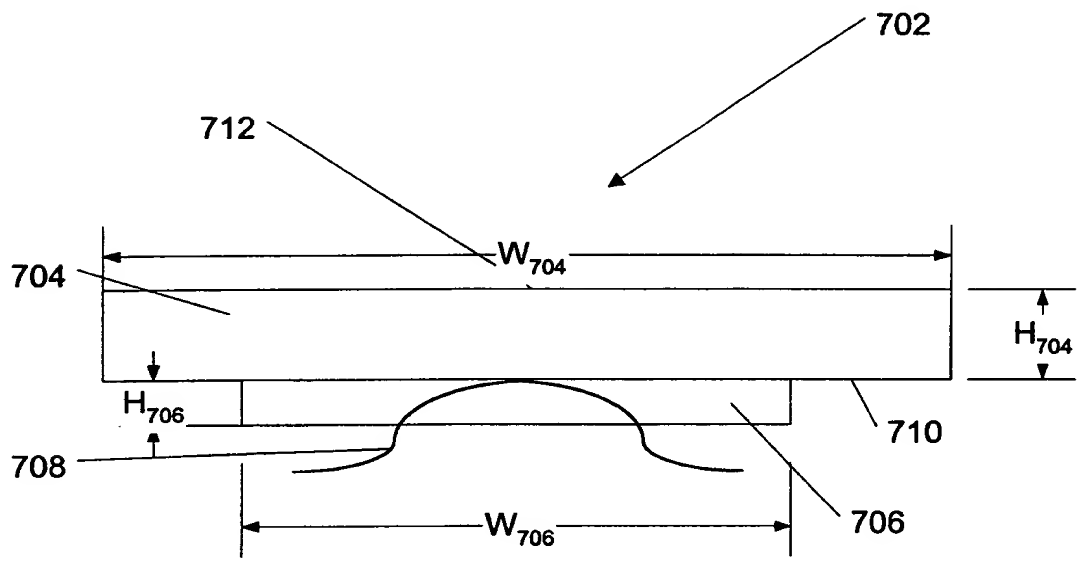

FIGURE 12L

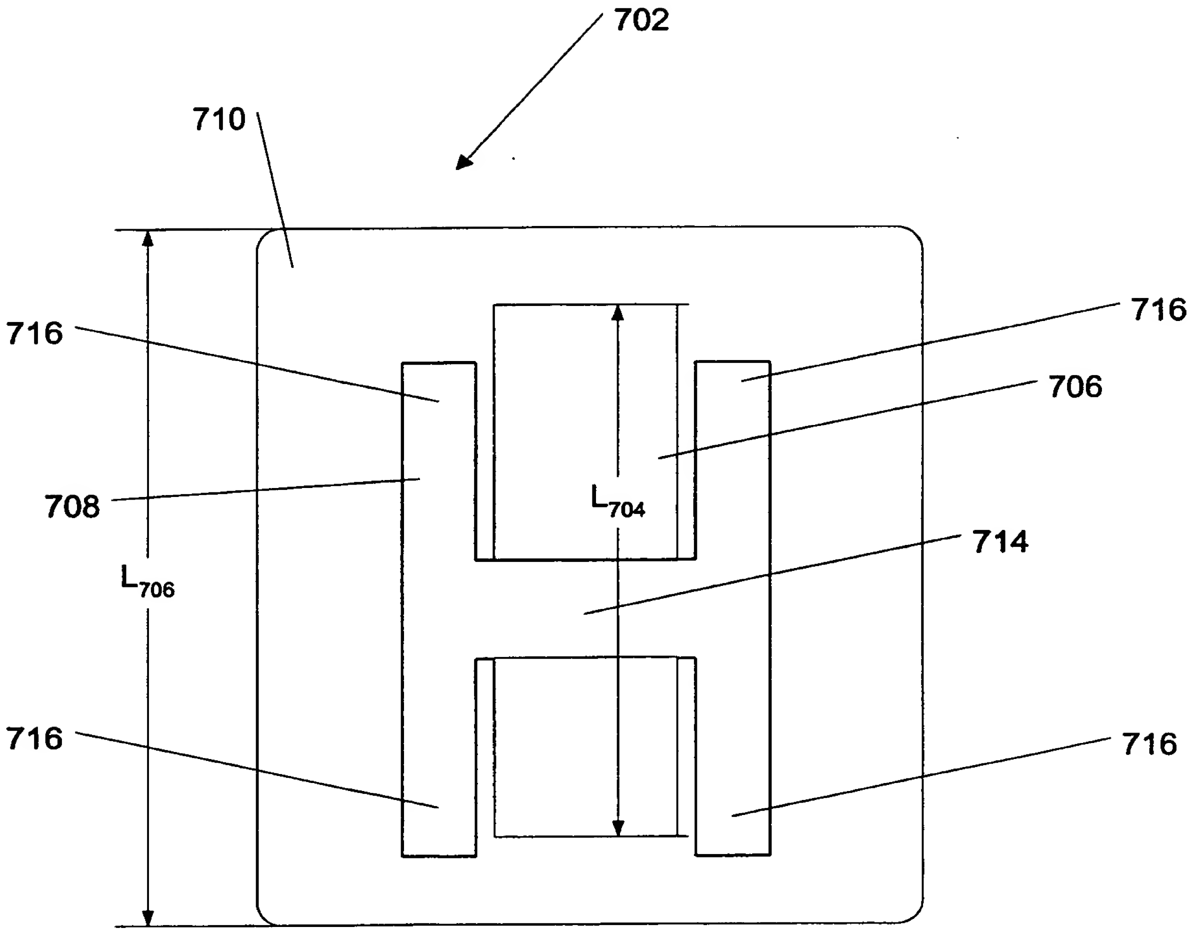

FIGURE 12M

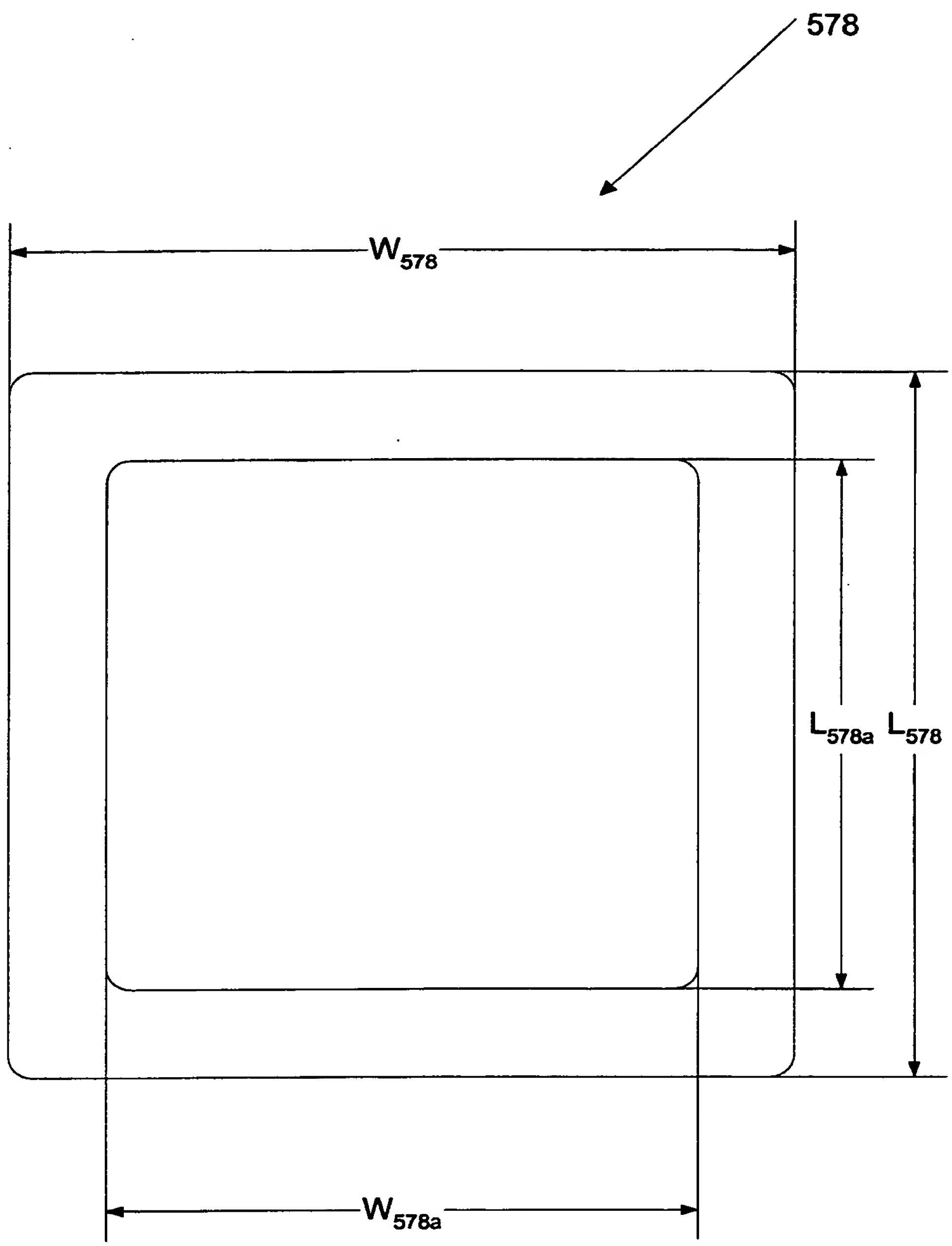

FIGURE 12N

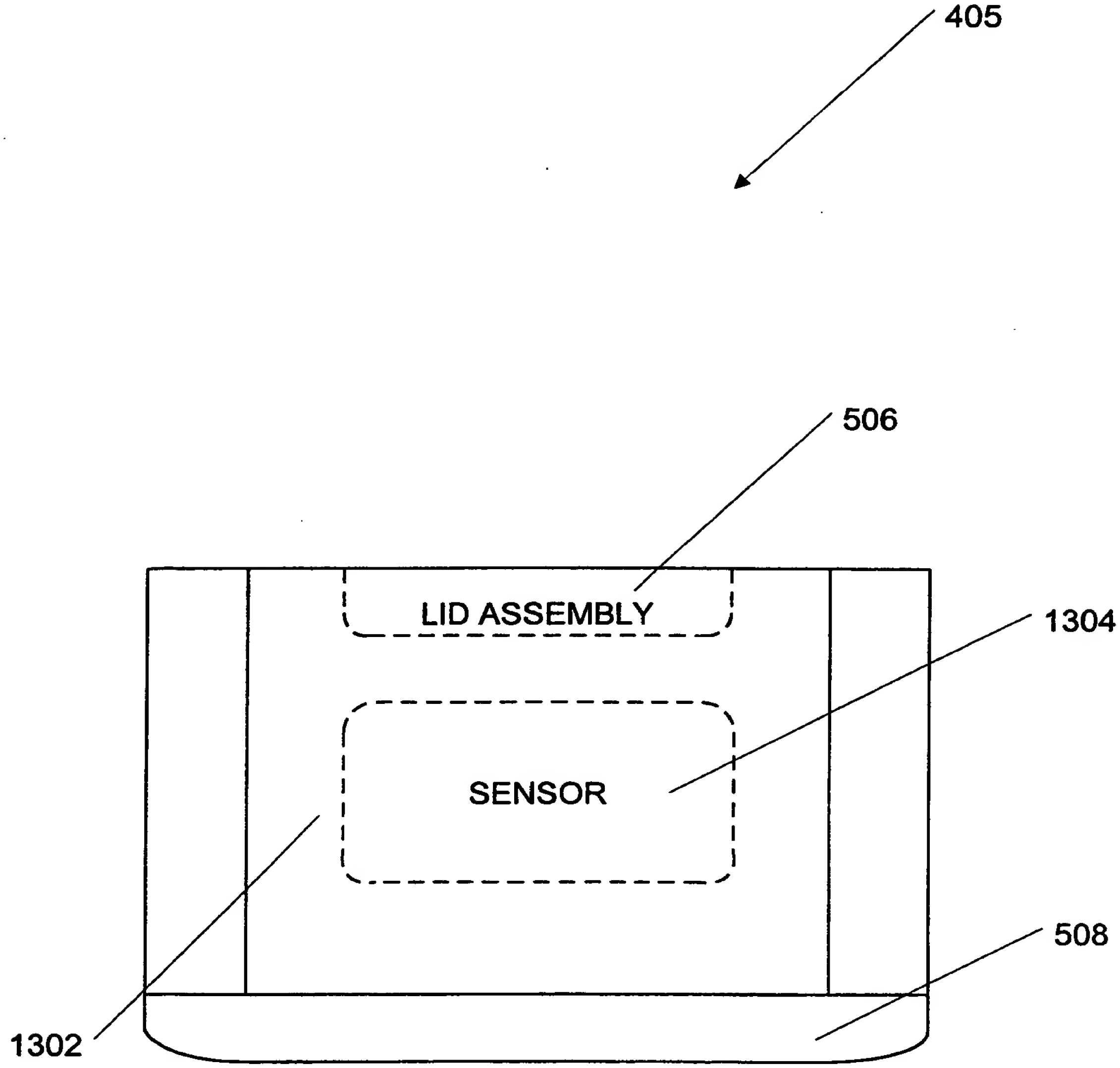

FIGURE 13A

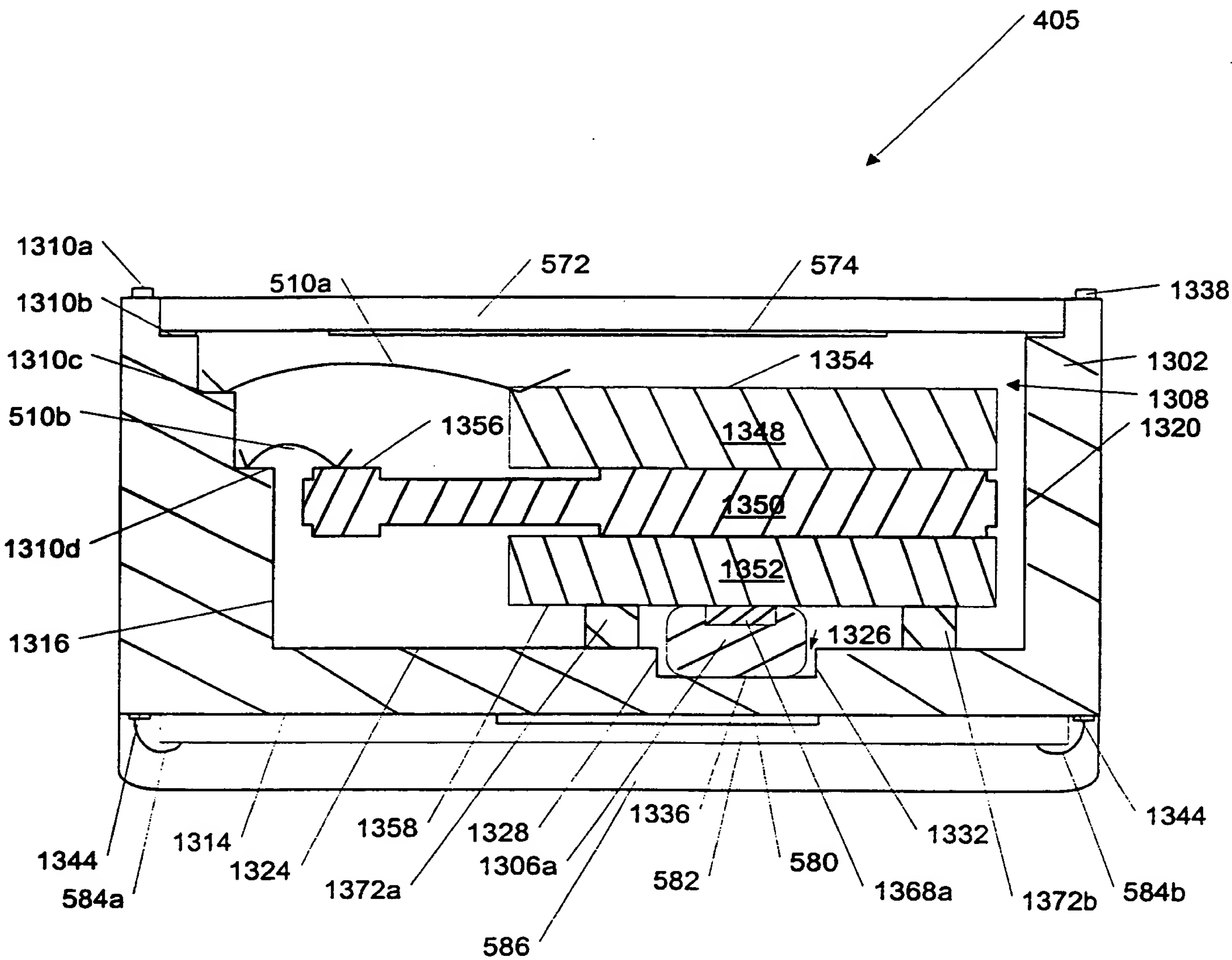
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FIGURE 13B

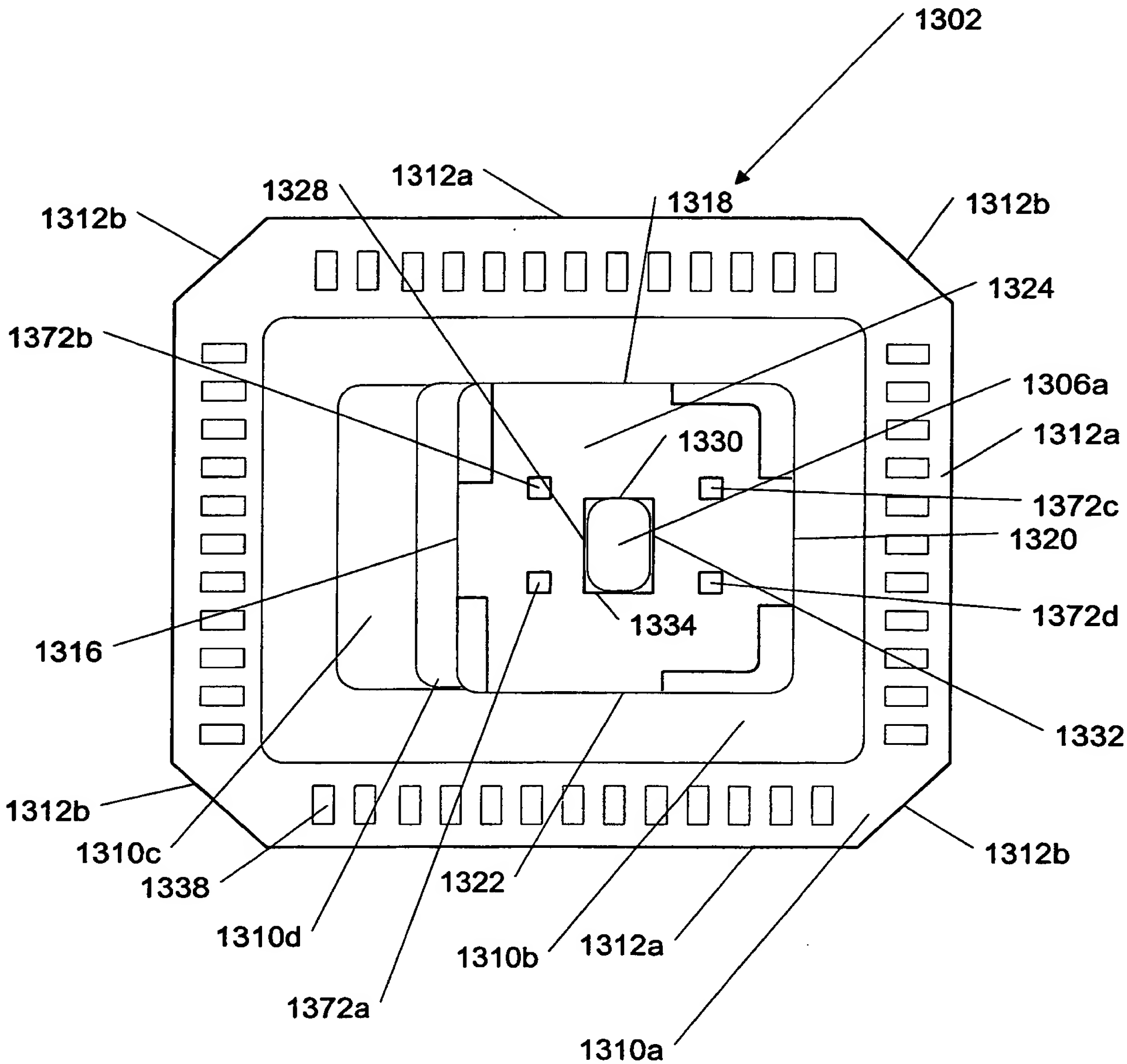
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FIGURE 13C

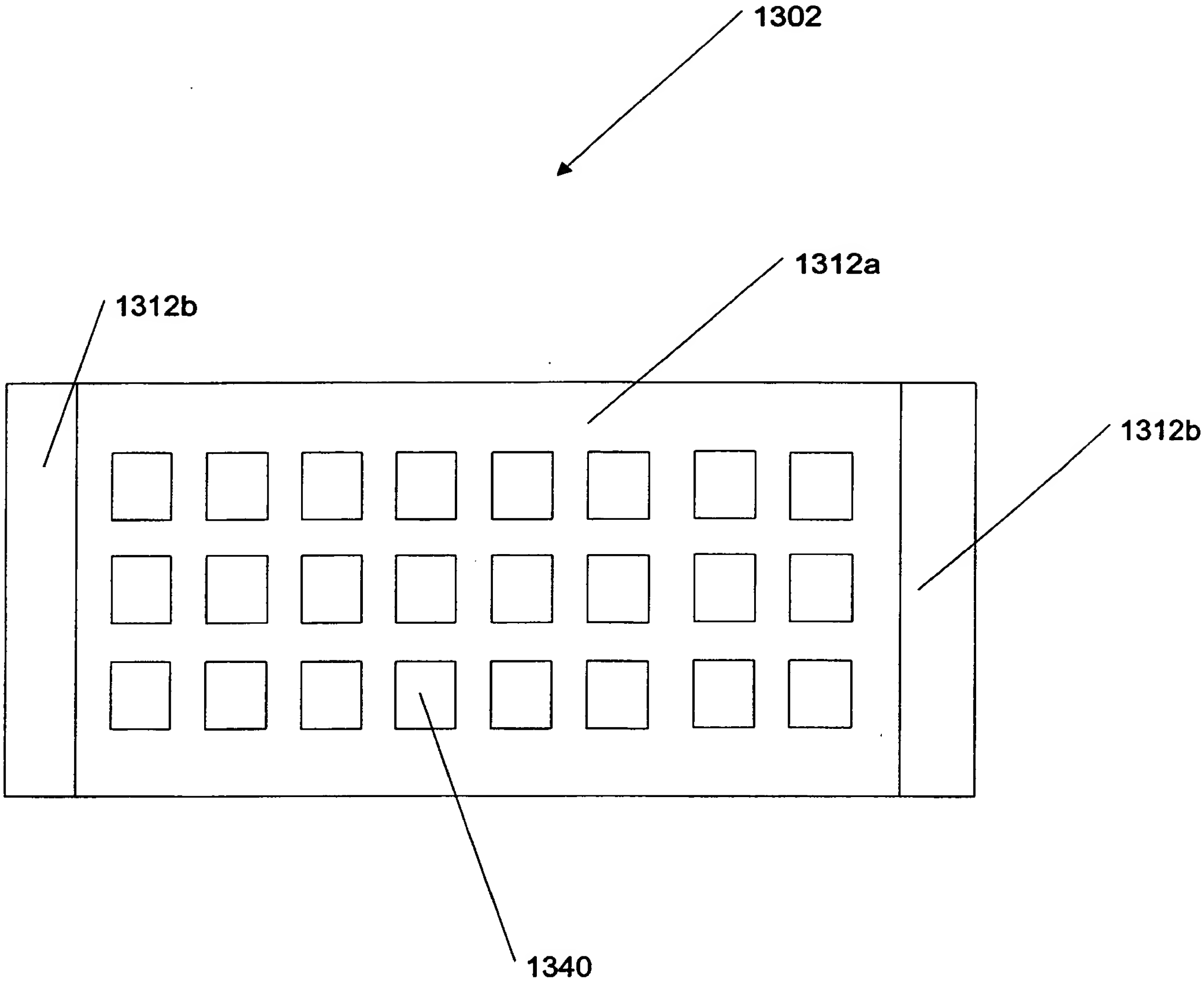

FIGURE 13D

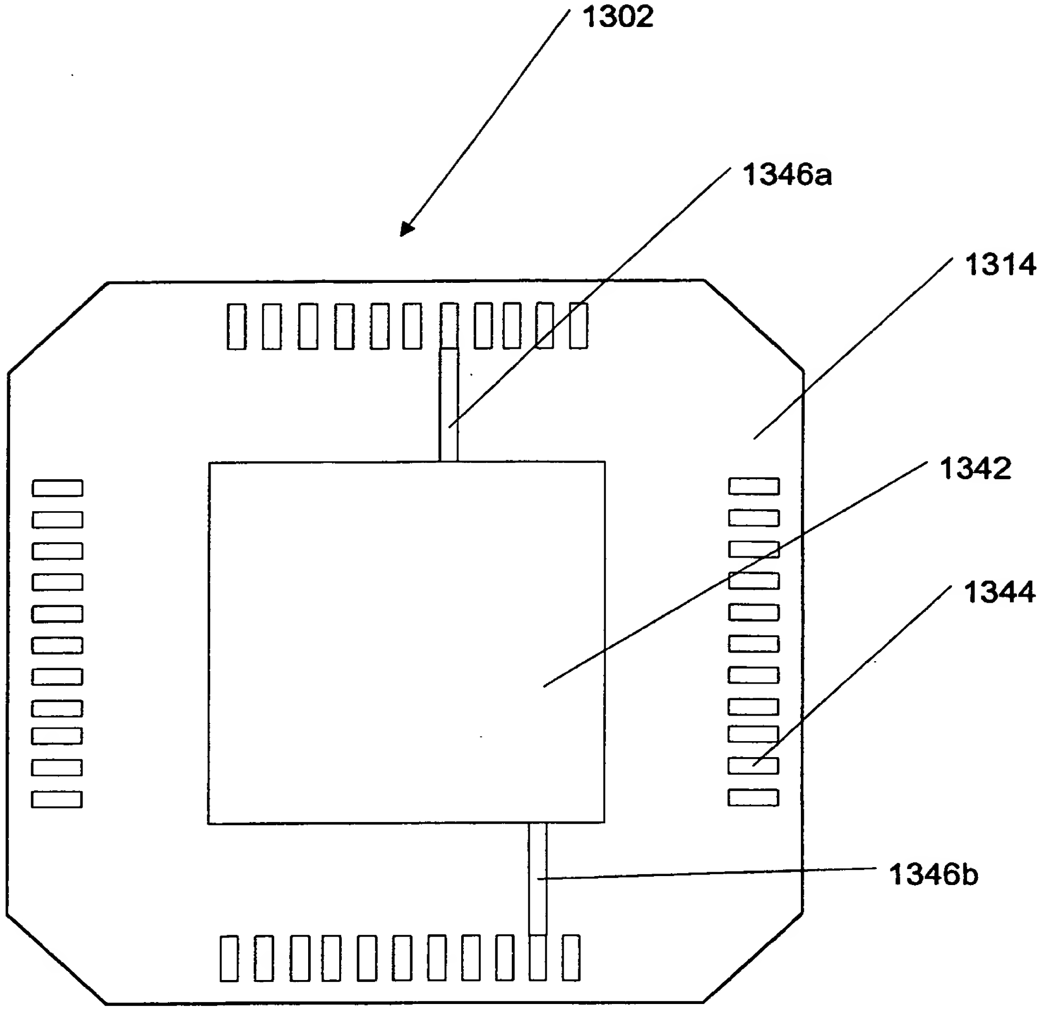

FIGURE 13E

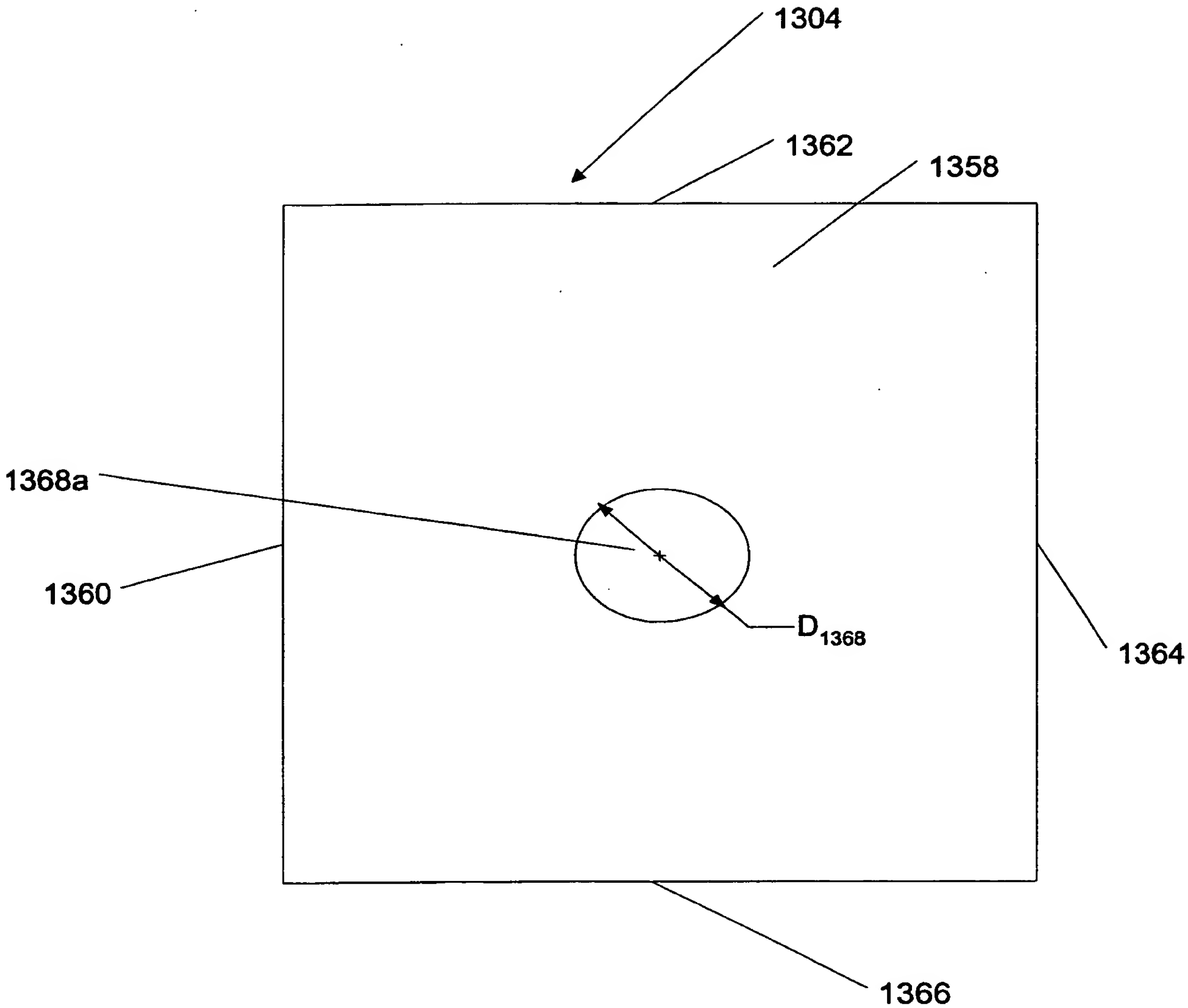

FIGURE 13F

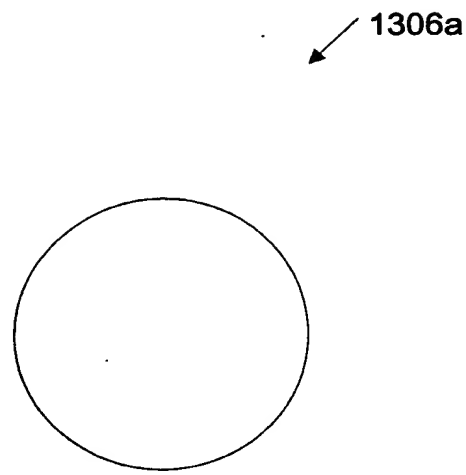

FIGURE 13G

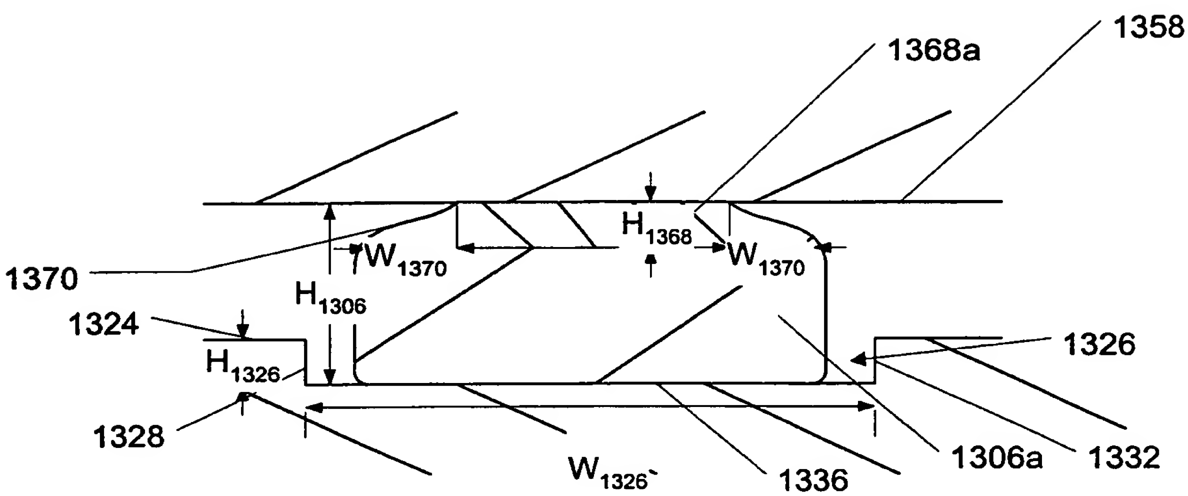

FIGURE 13H

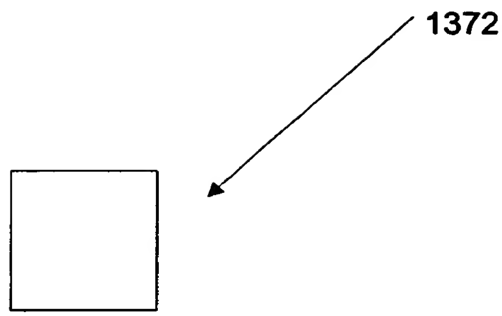

FIGURE 13I

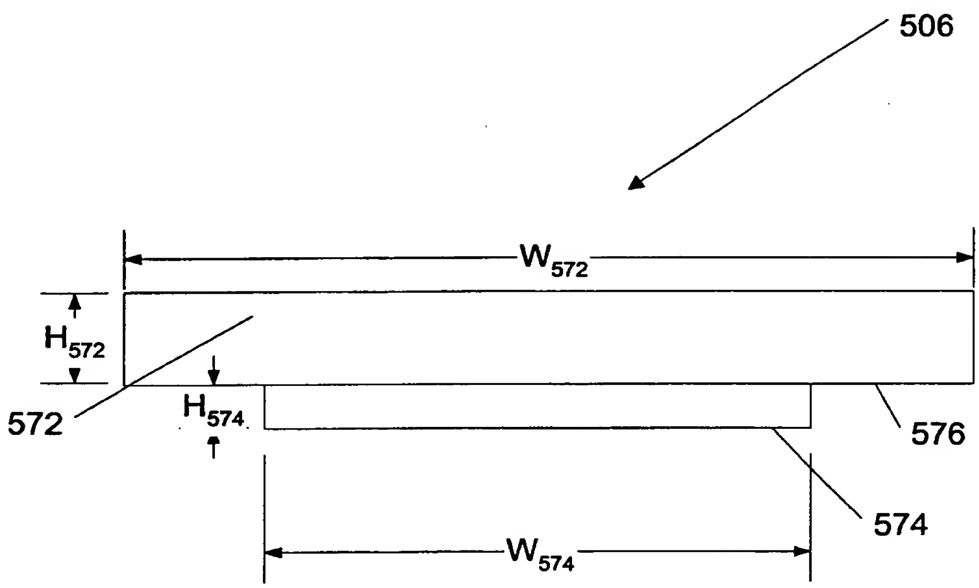

FIGURE 13J

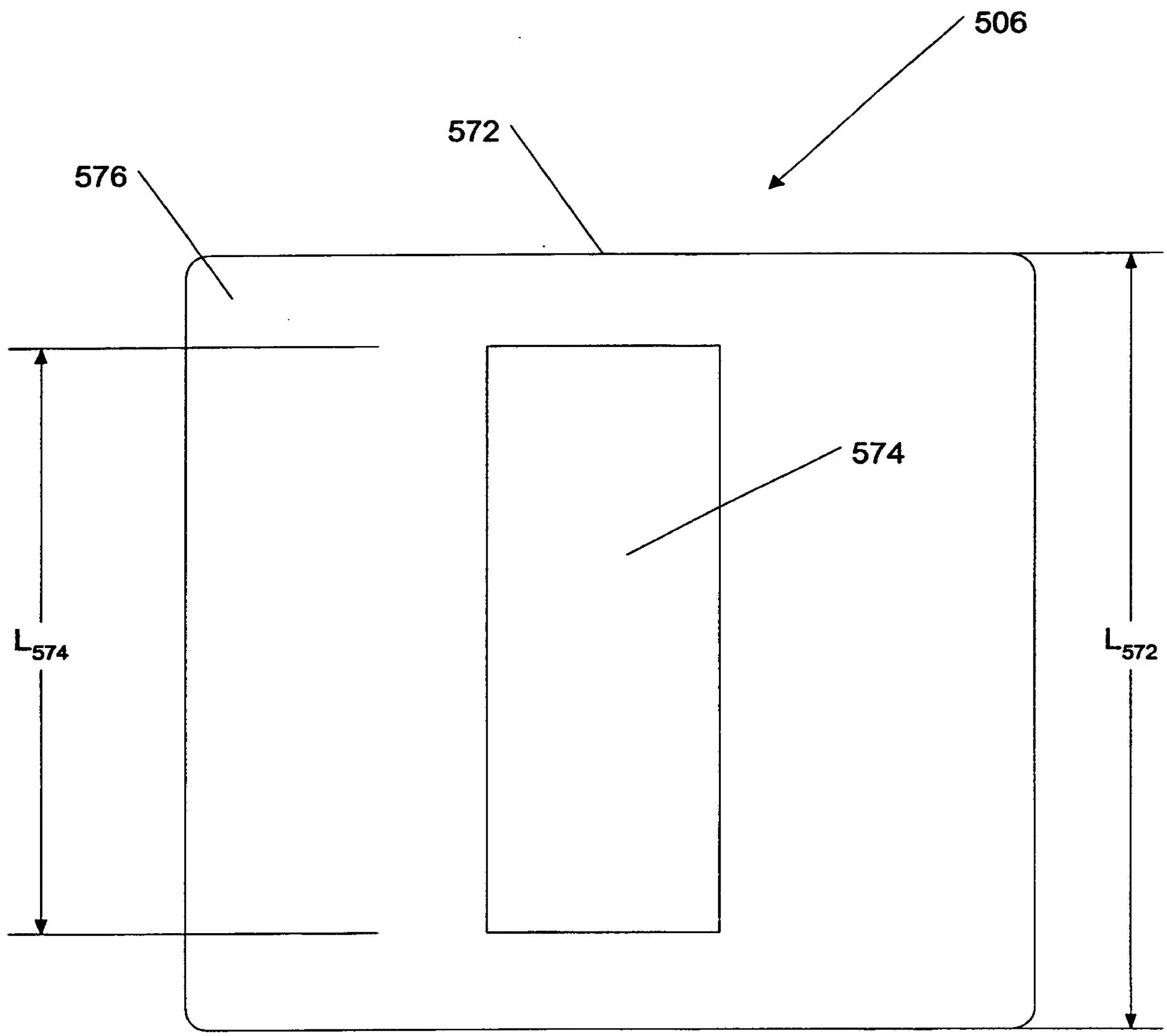

FIGURE 13K

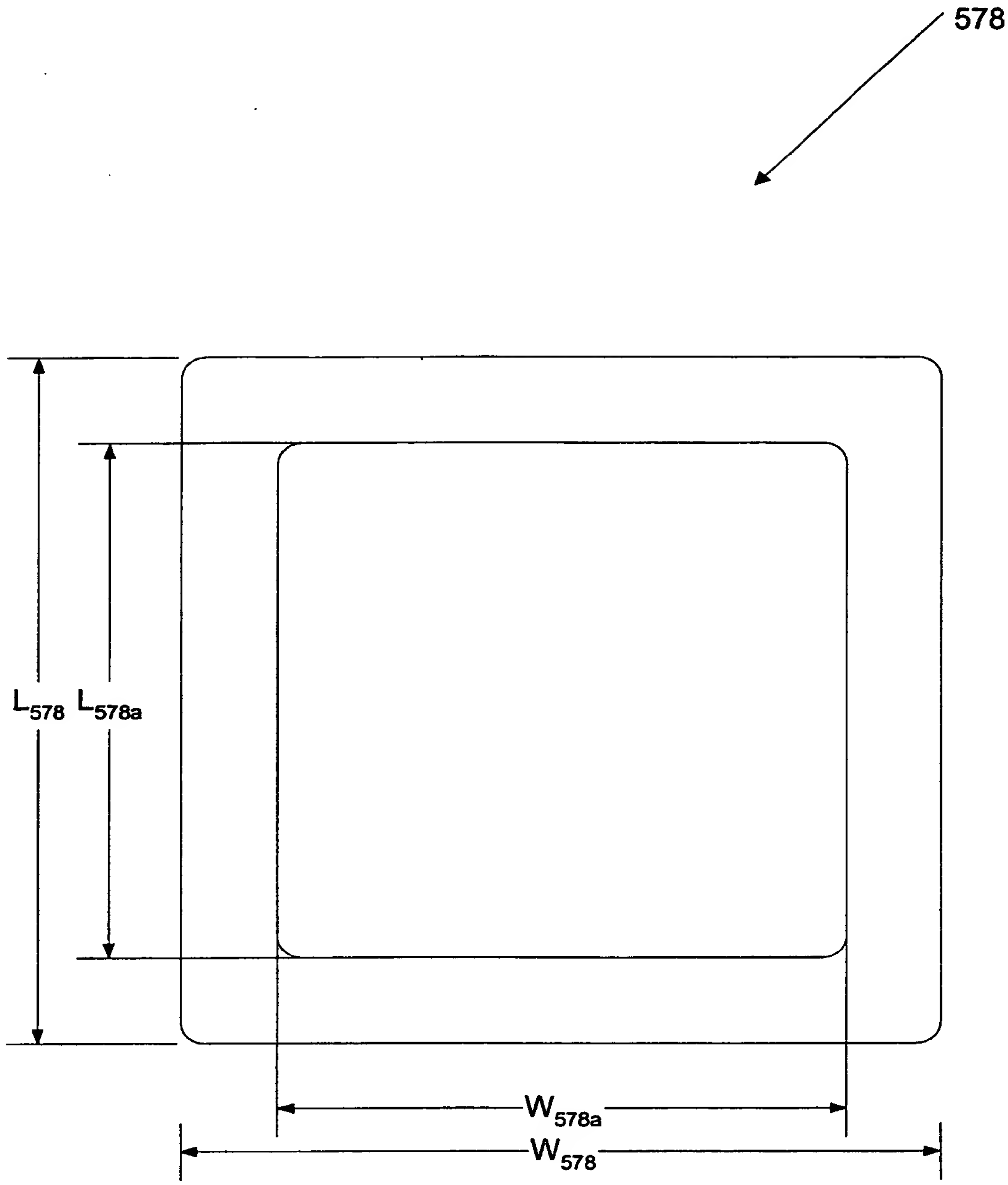

FIGURE 13L

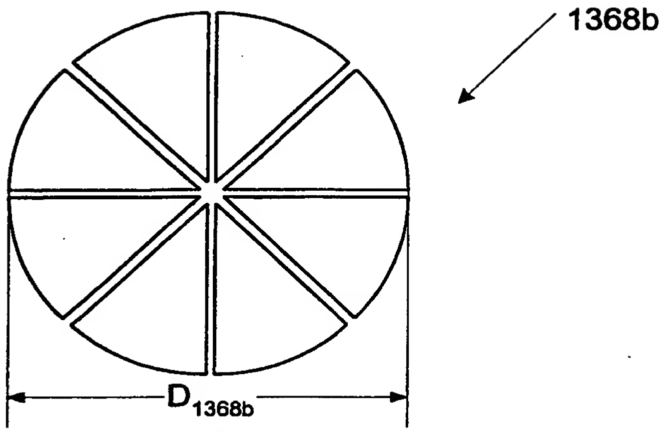

FIGURE 13M

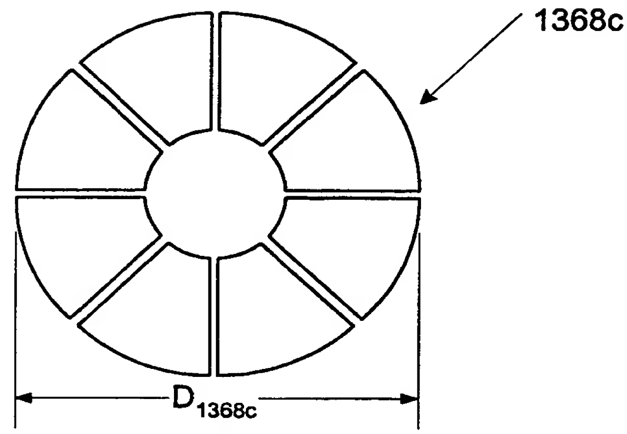

FIGURE 13N

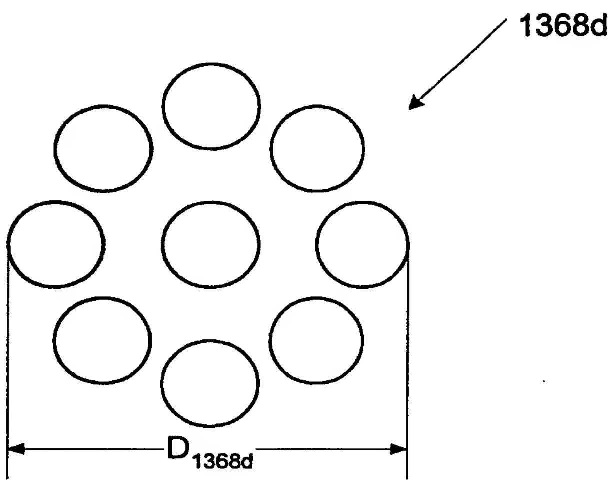

FIGURE 13O

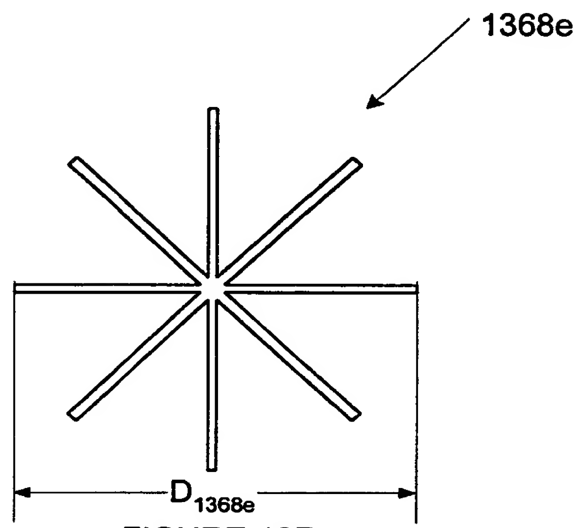

FIGURE 13P

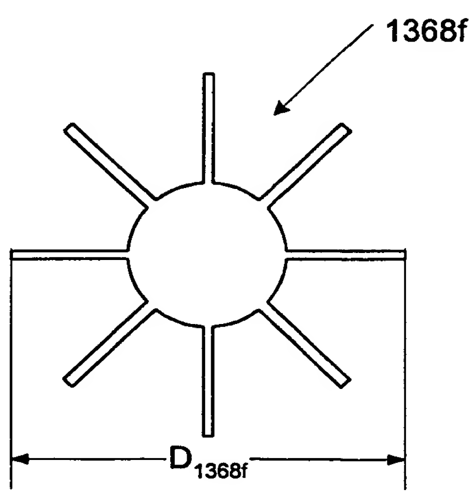

FIGURE 13Q

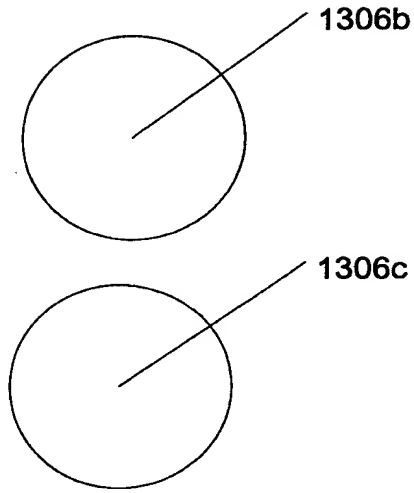

FIGURE 13V

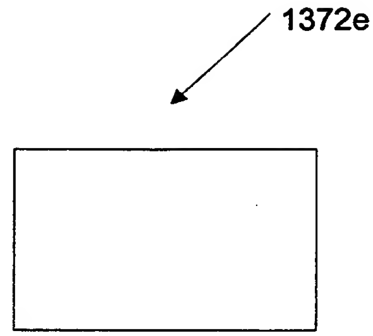

FIGURE 13W

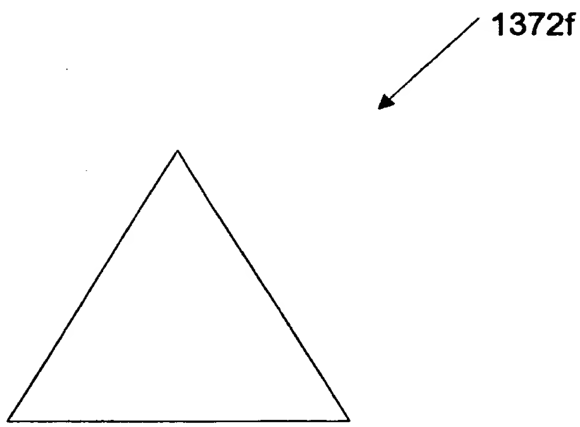

FIGURE 13X

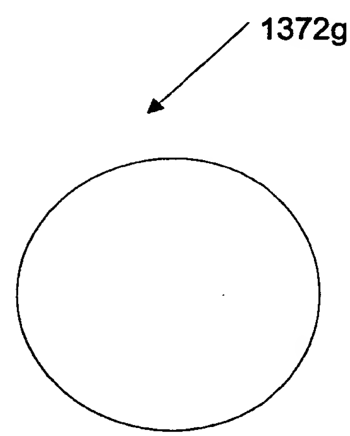

FIGURE 13Y

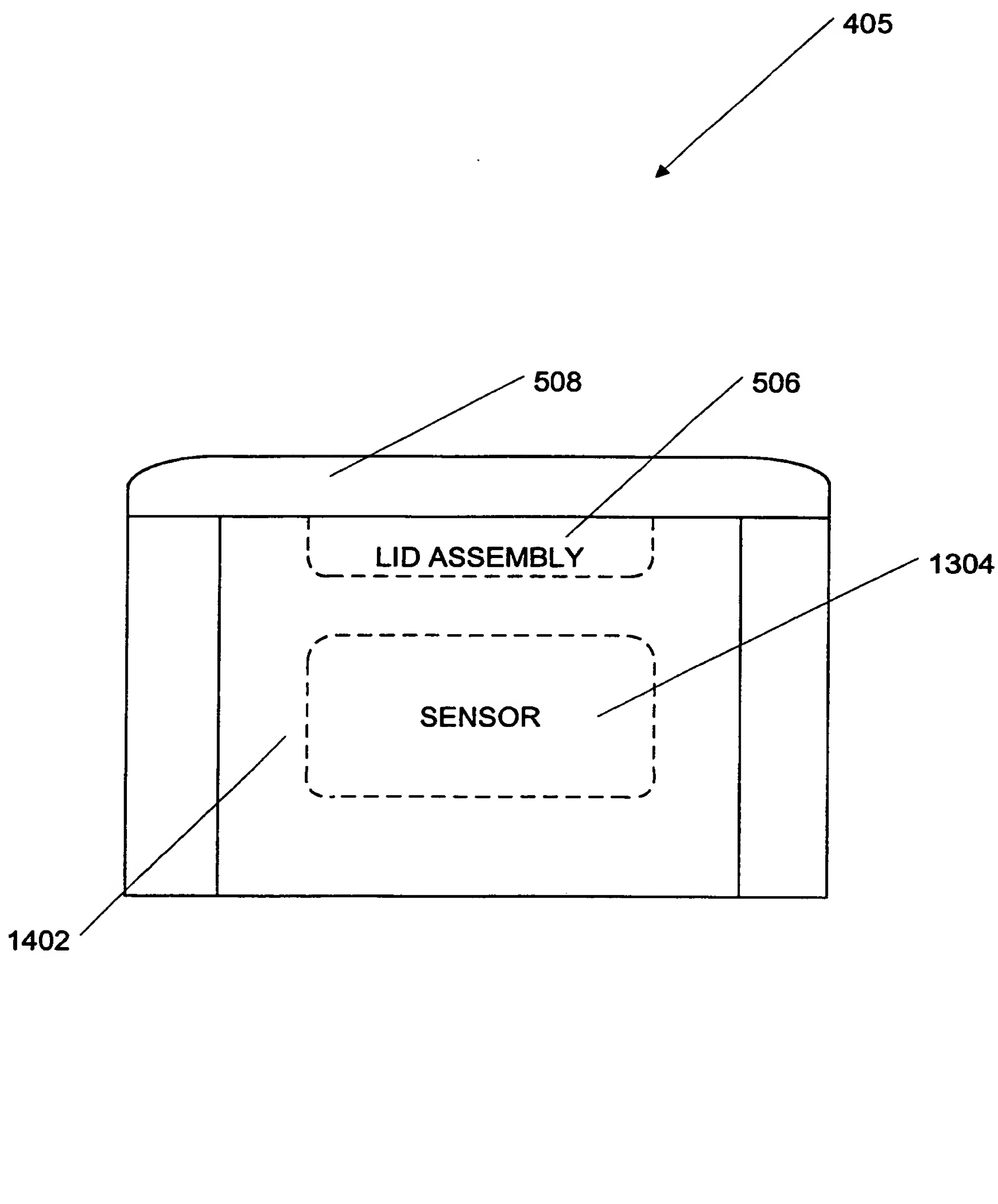

FIGURE 14A

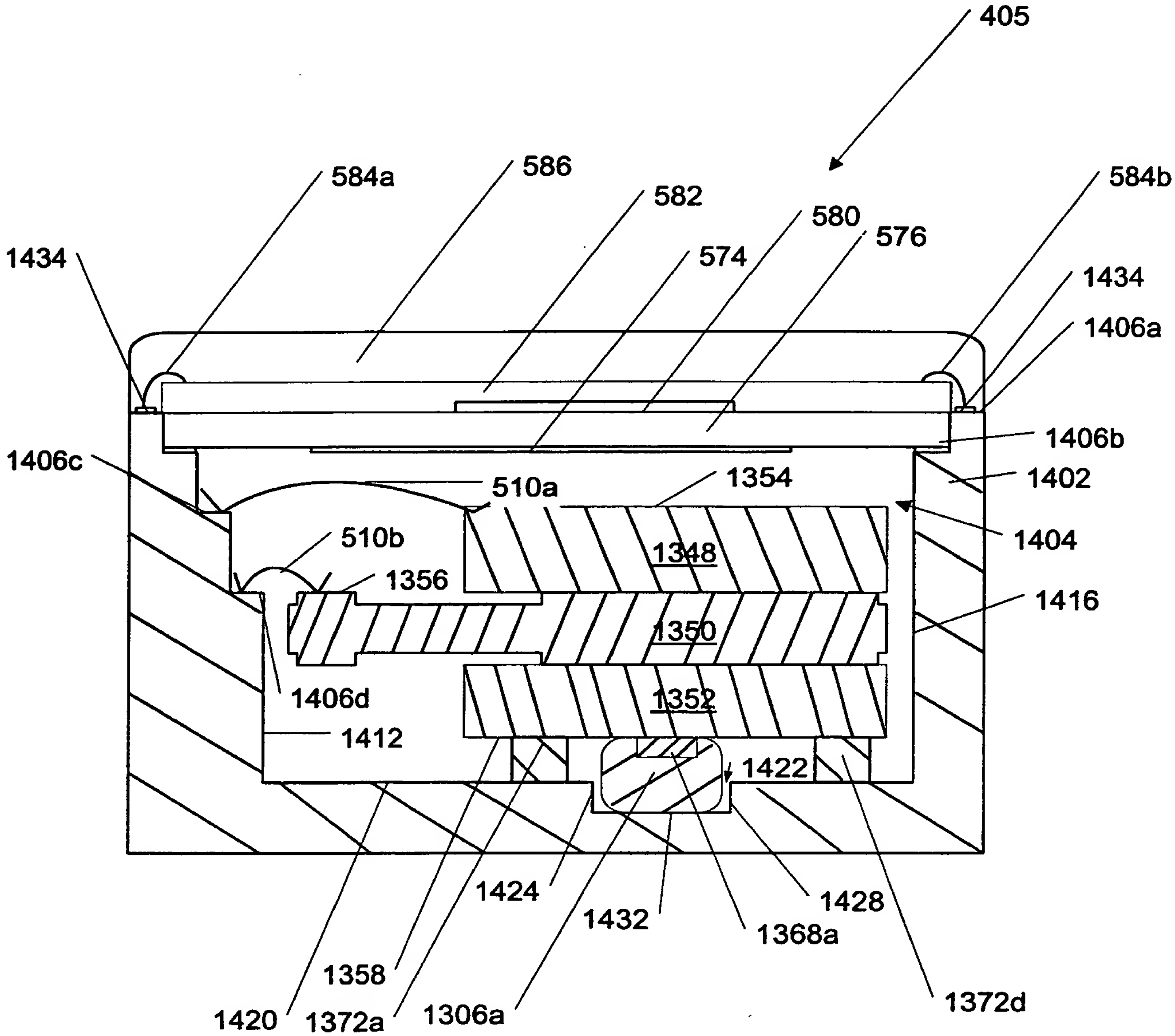
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FIGURE 14B

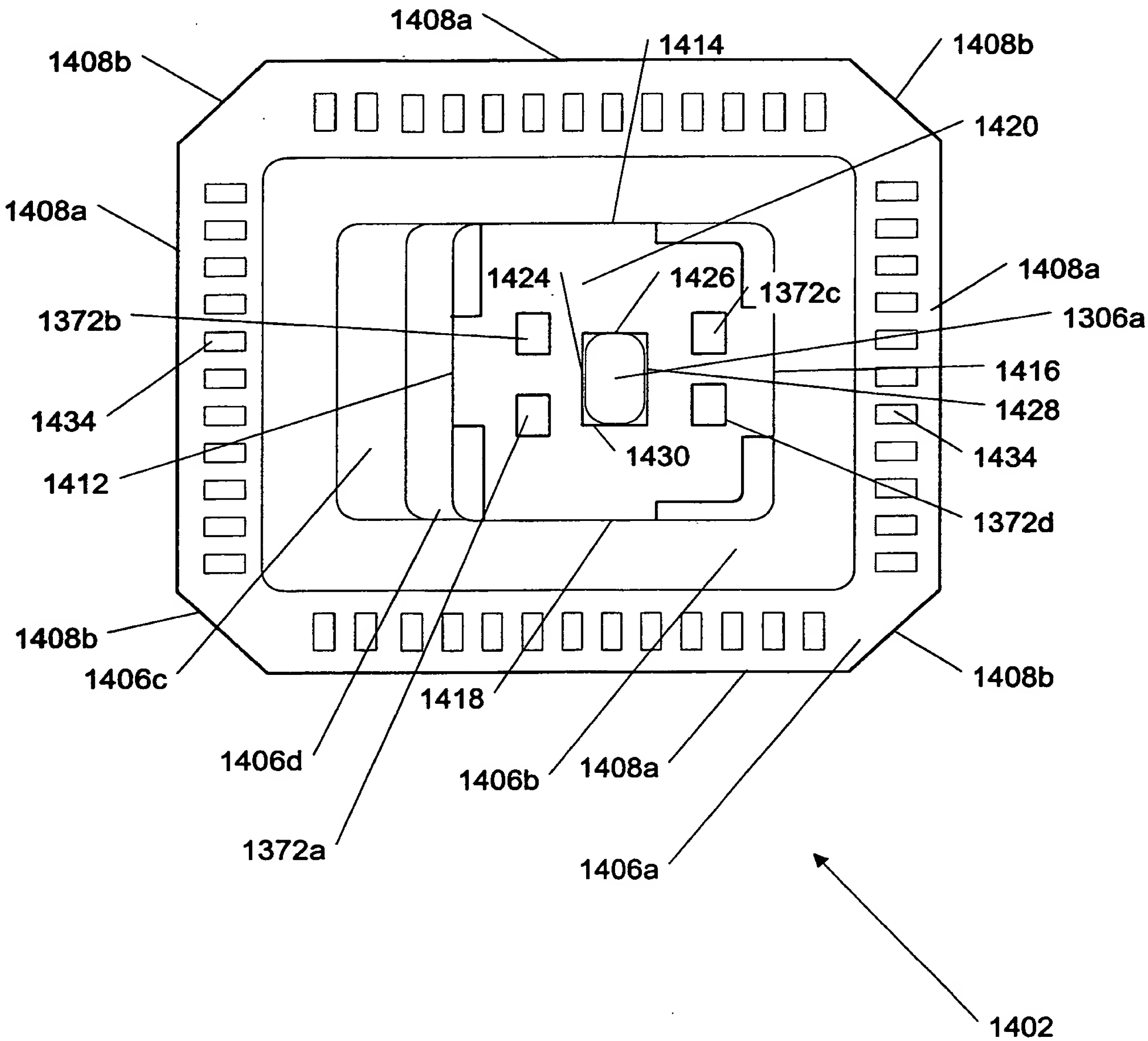
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FIGURE 14C

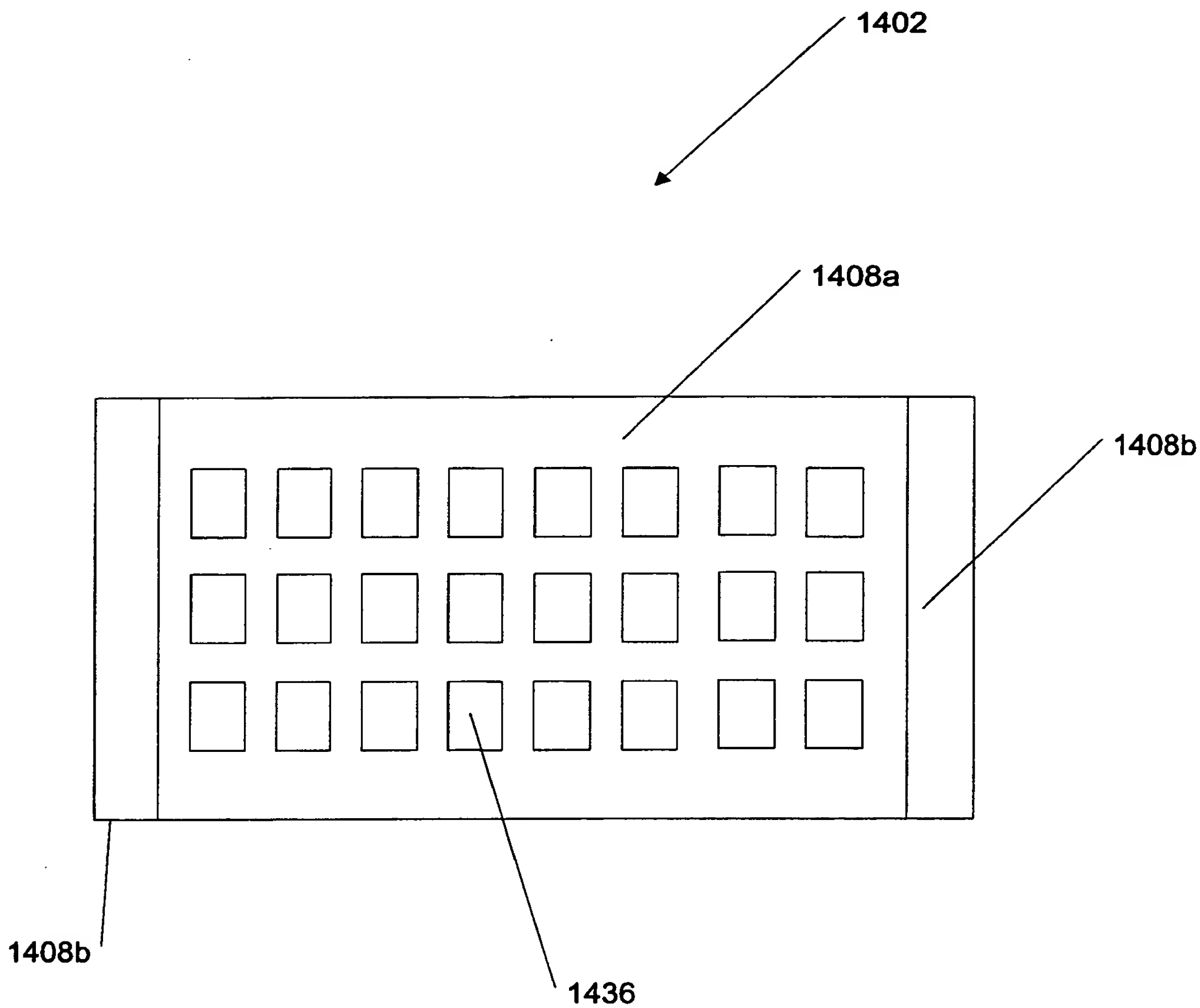

FIGURE 14D

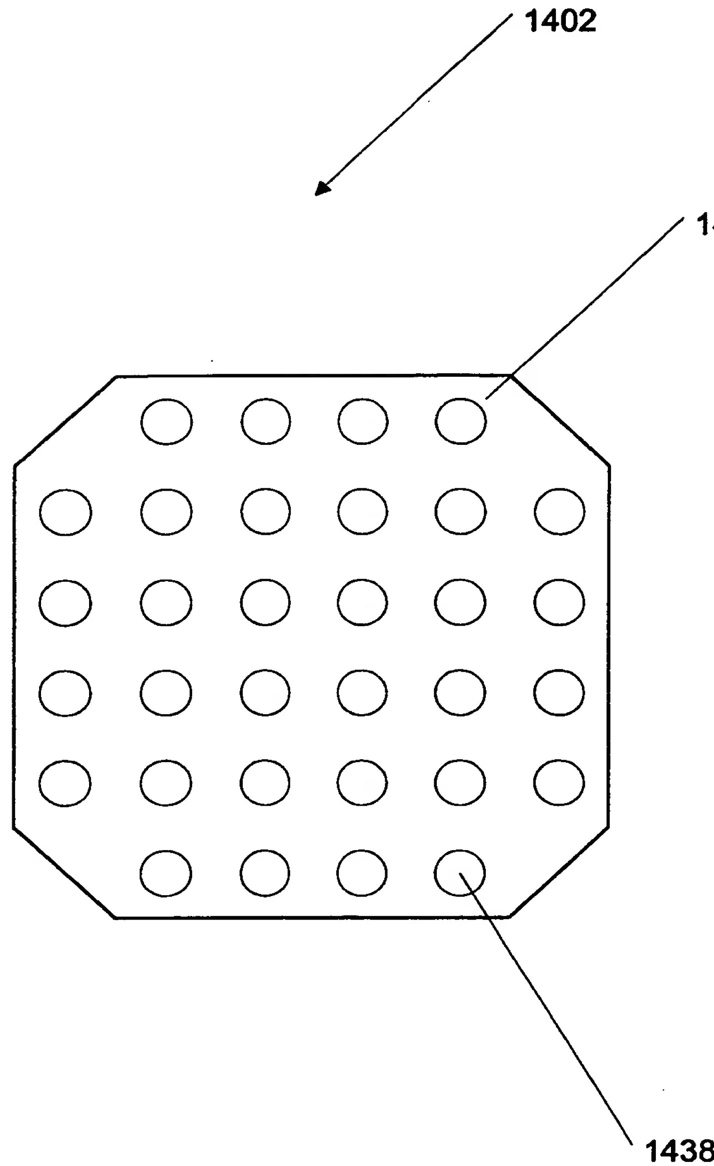

FIGURE 14E

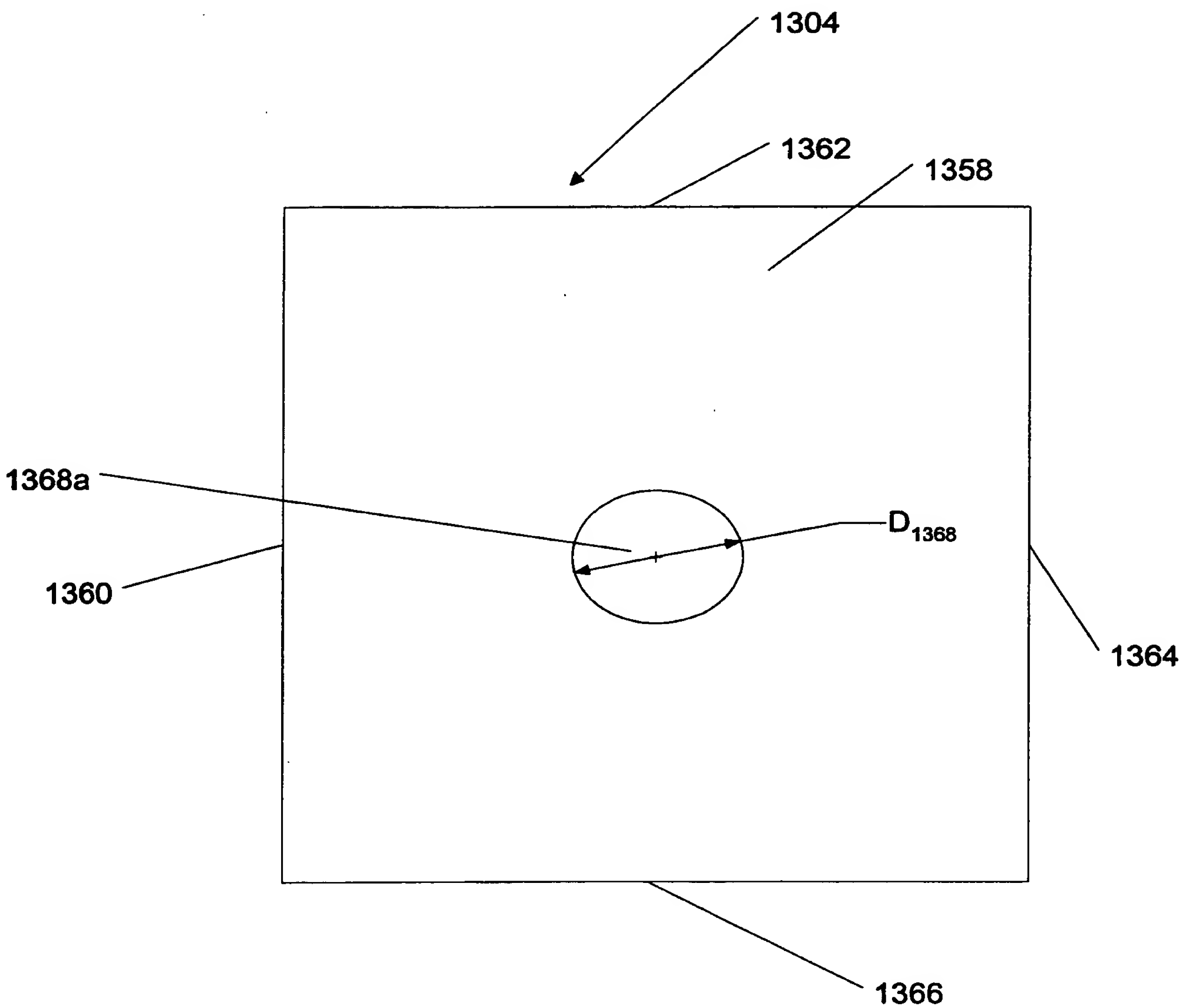

FIGURE 14F

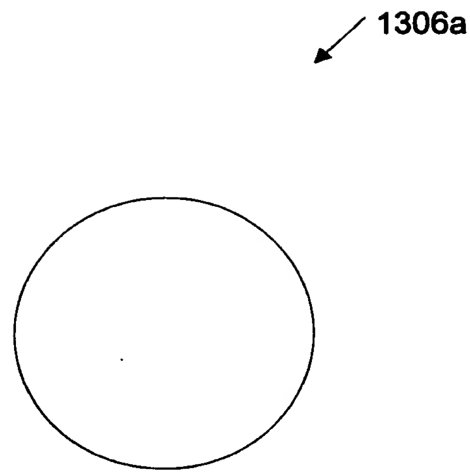

FIGURE 14G

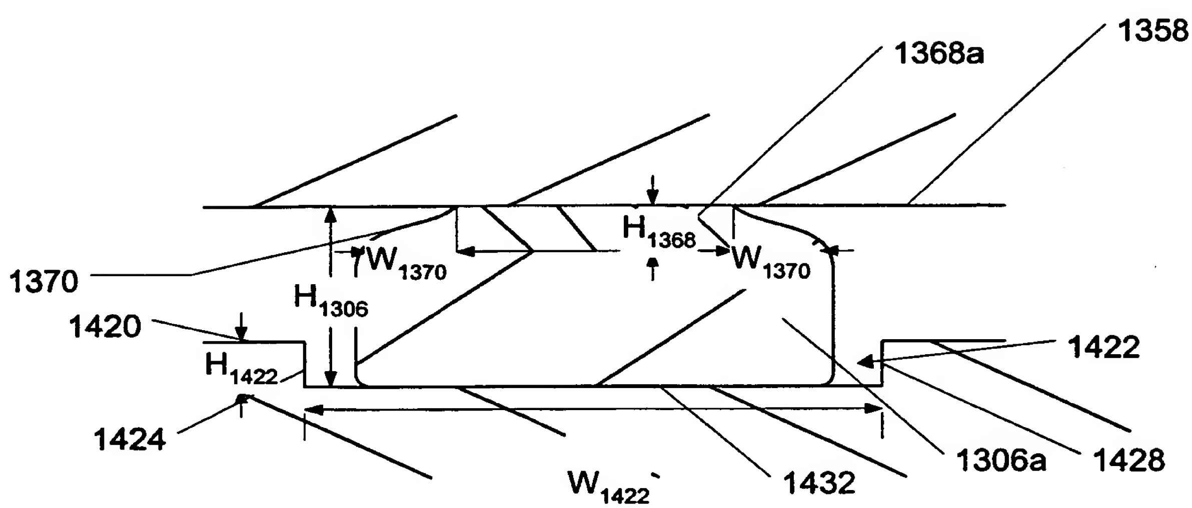

FIGURE 14H

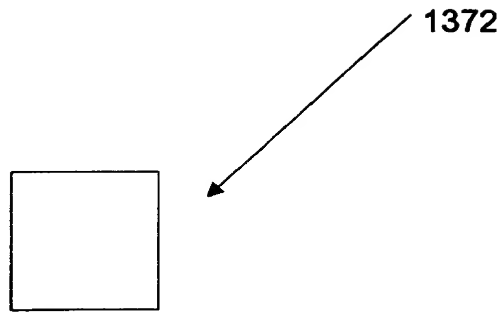

FIGURE 14I

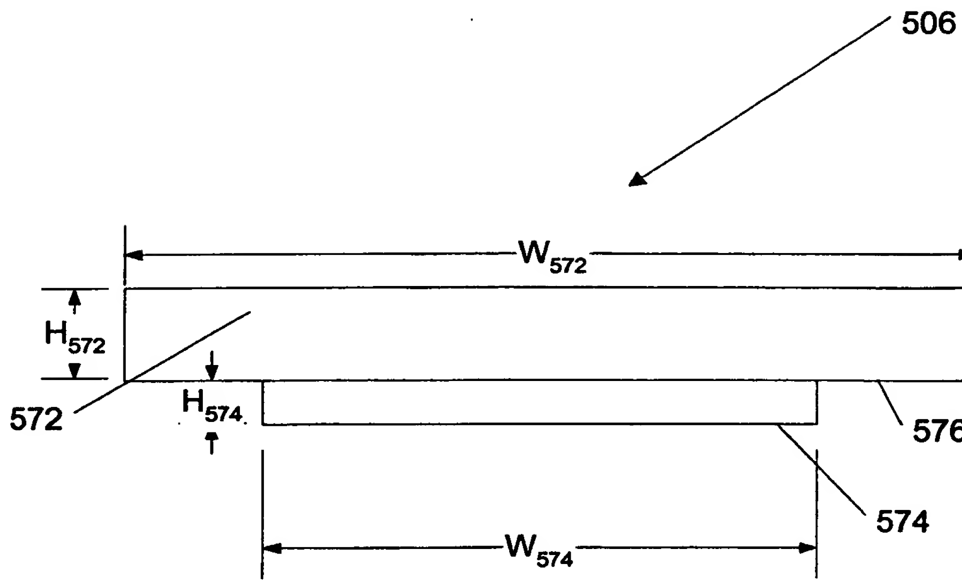

FIGURE 14J

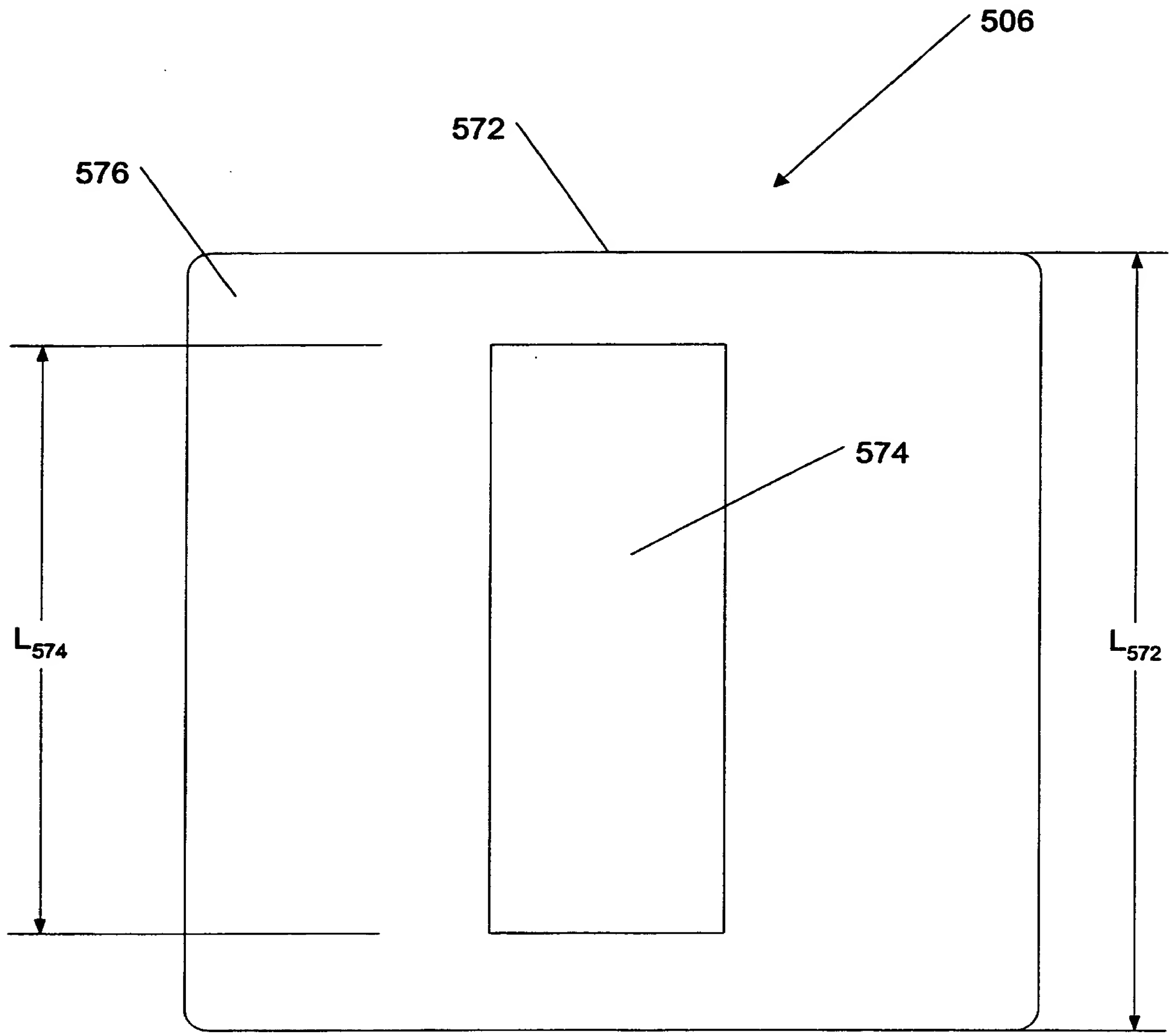

FIGURE 14K

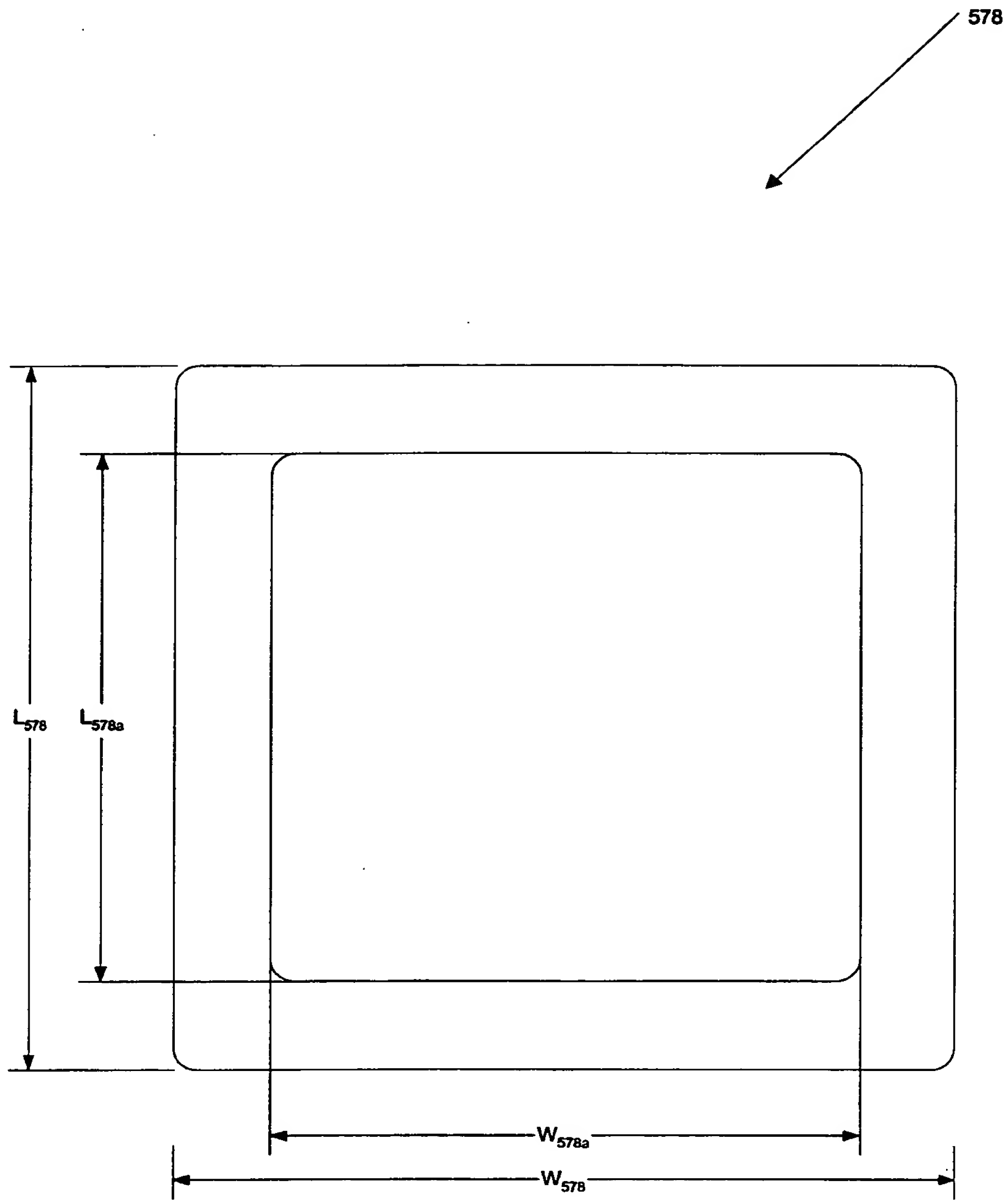

FIGURE 14L

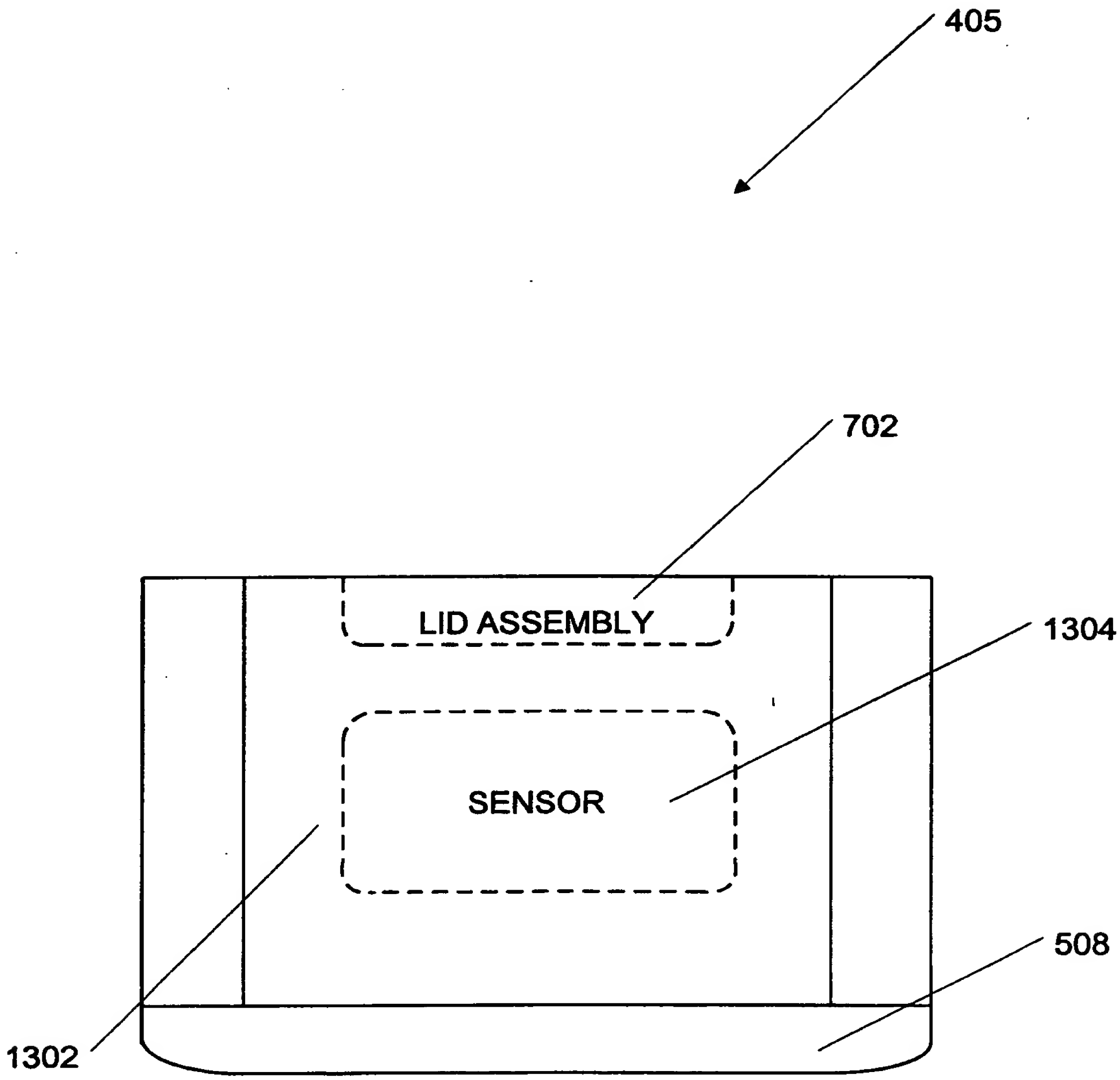

FIGURE 15A

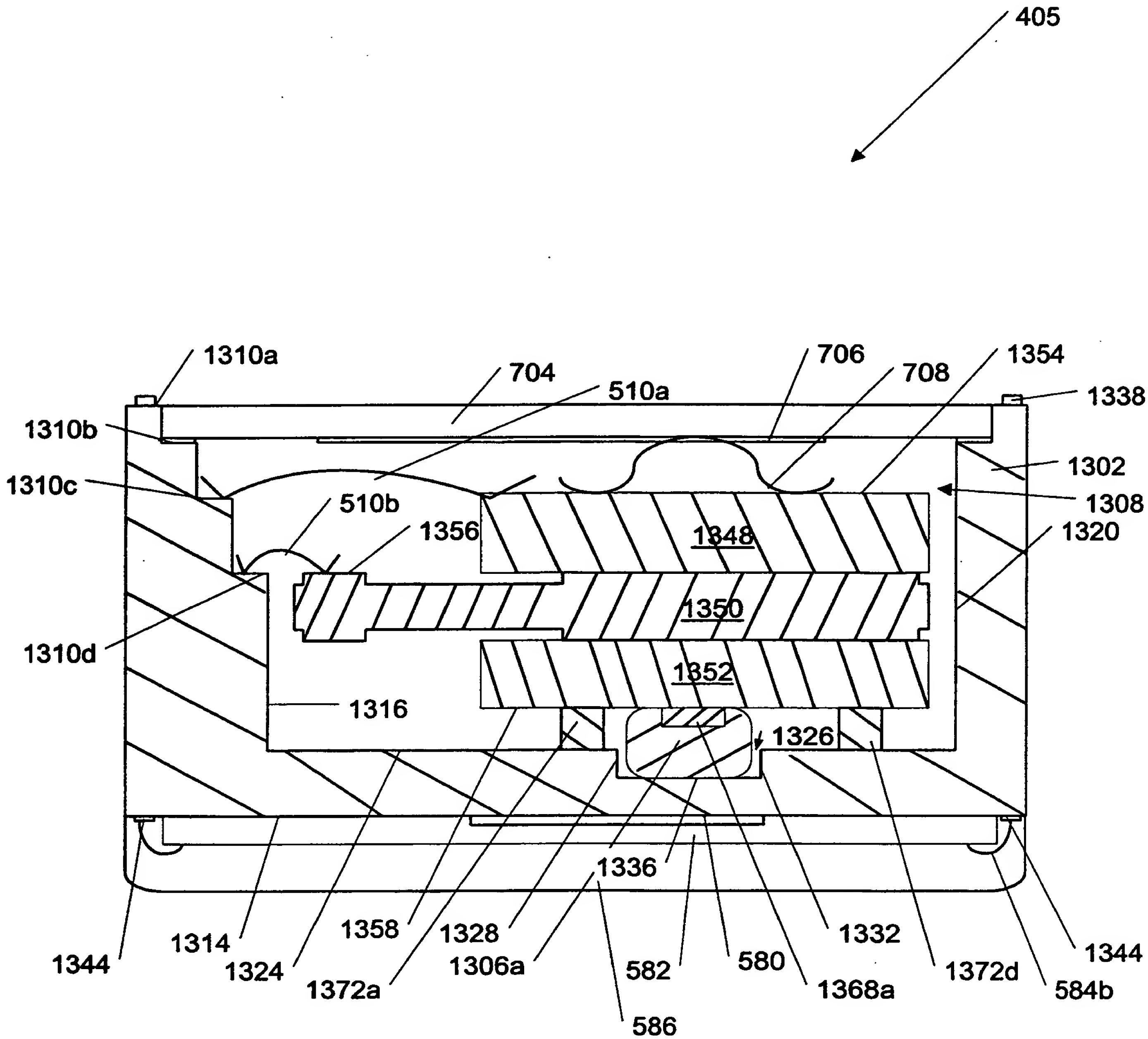
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FIGURE 15B

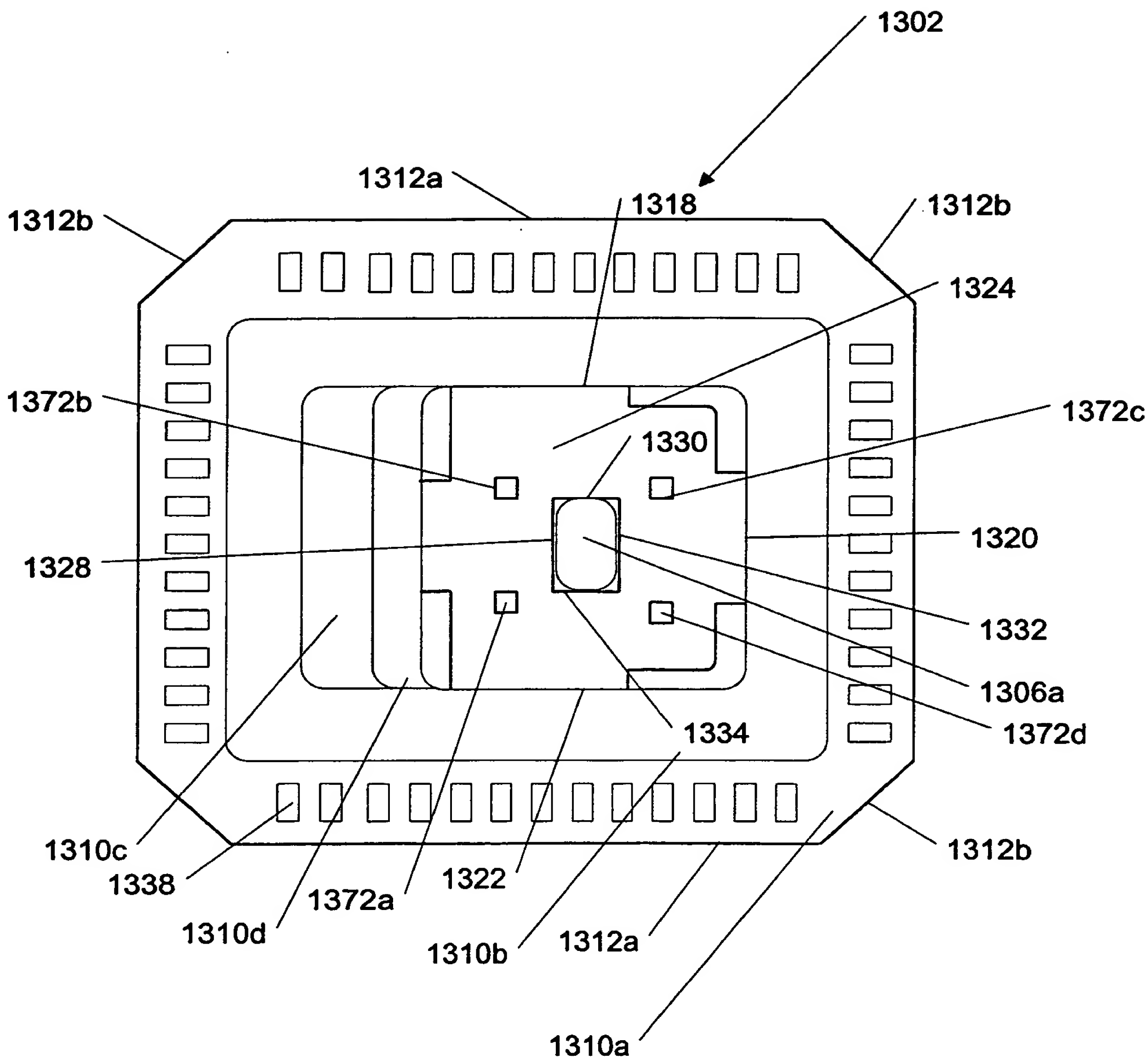
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FIGURE 15C

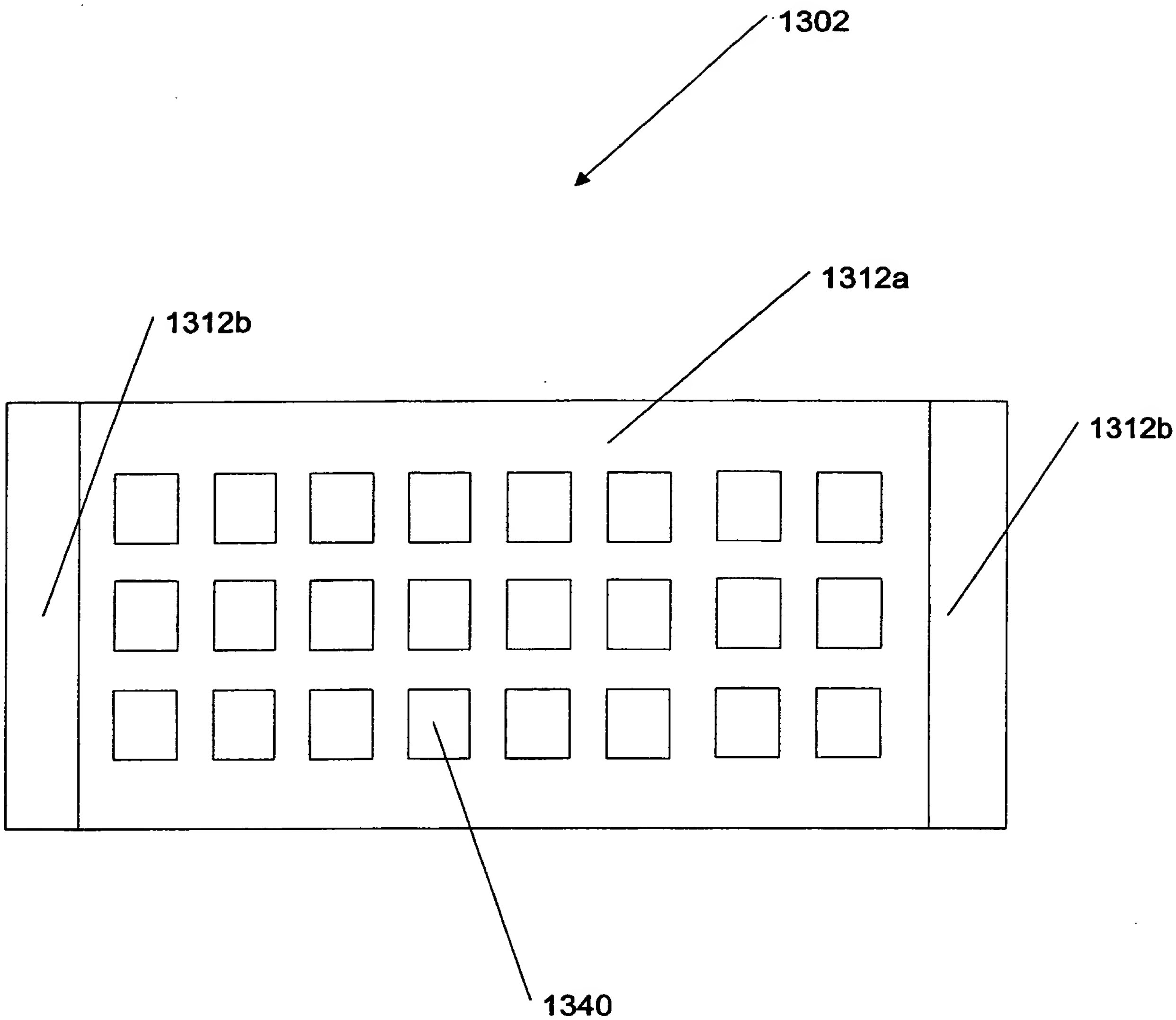

FIGURE 15D

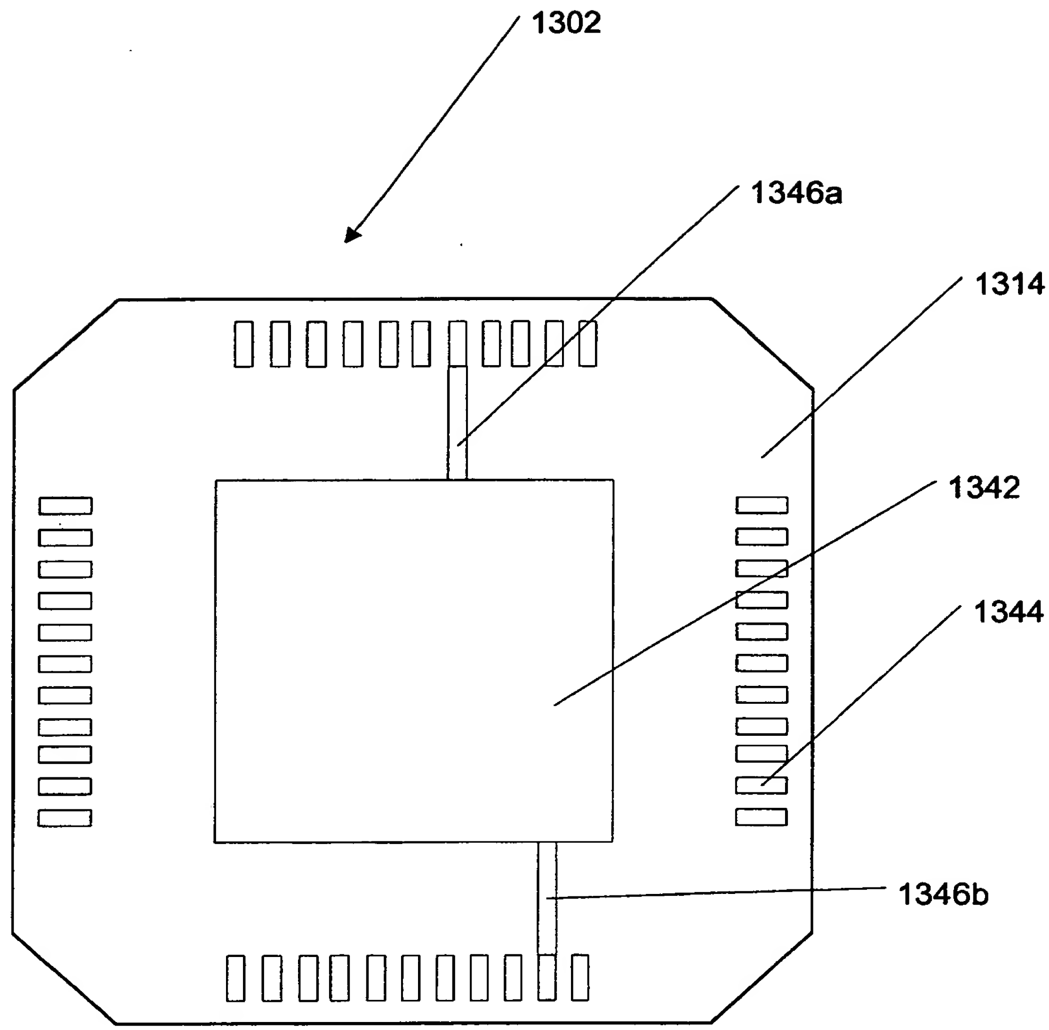

FIGURE 15E

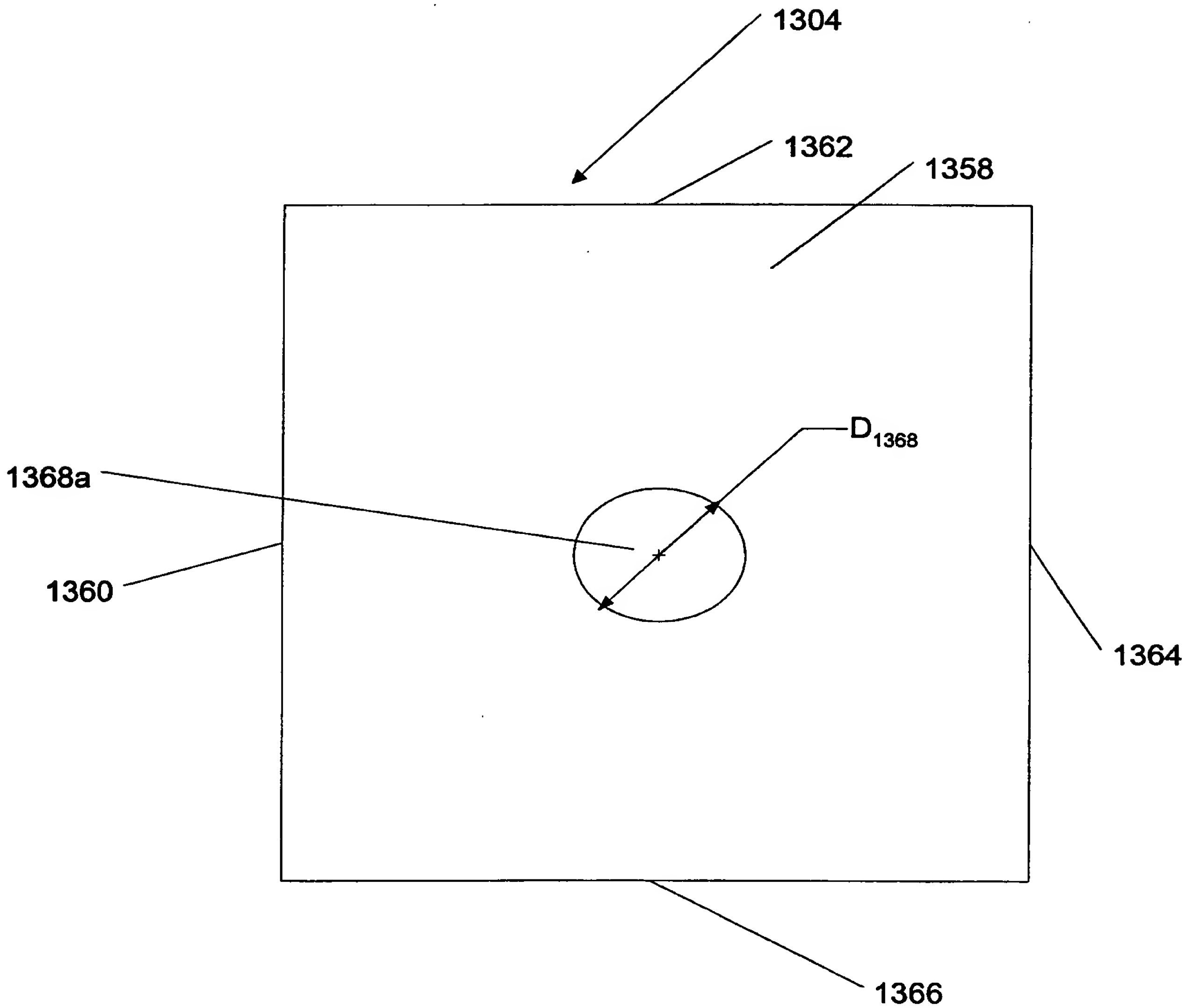

FIGURE 15F

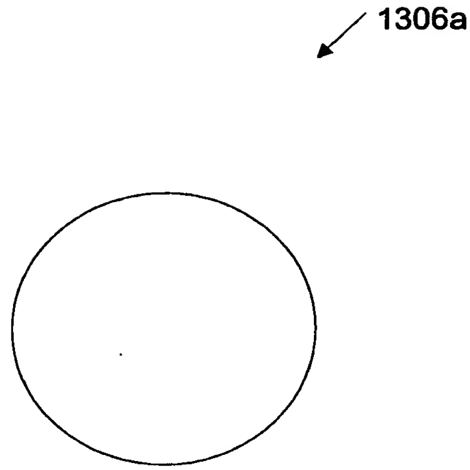

FIGURE 15G

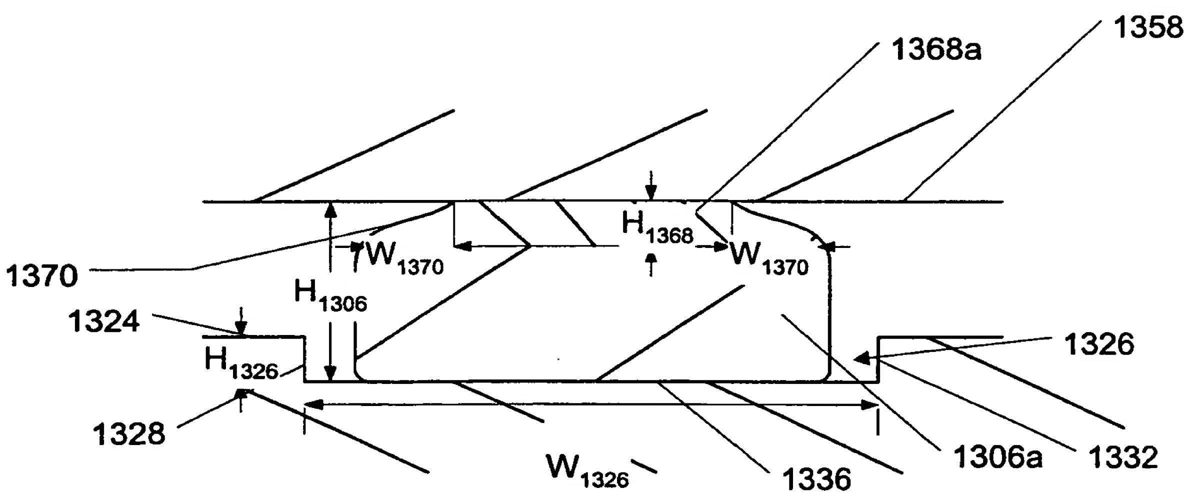

FIGURE 15H

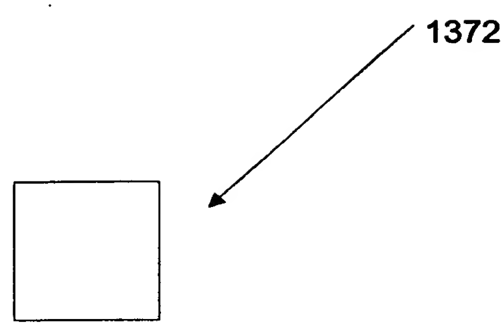

FIGURE 15I

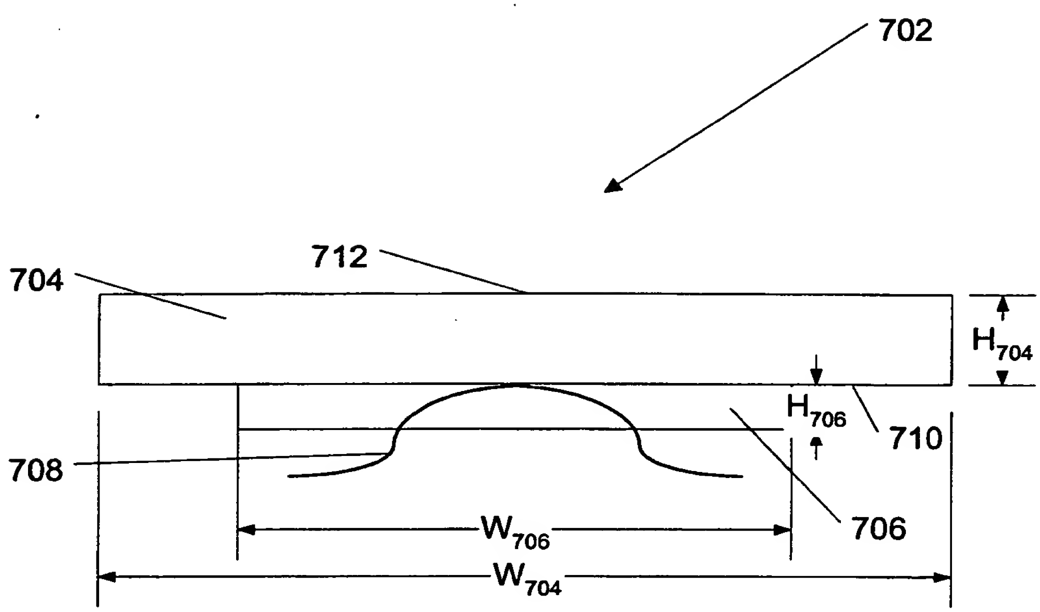

FIGURE 15J

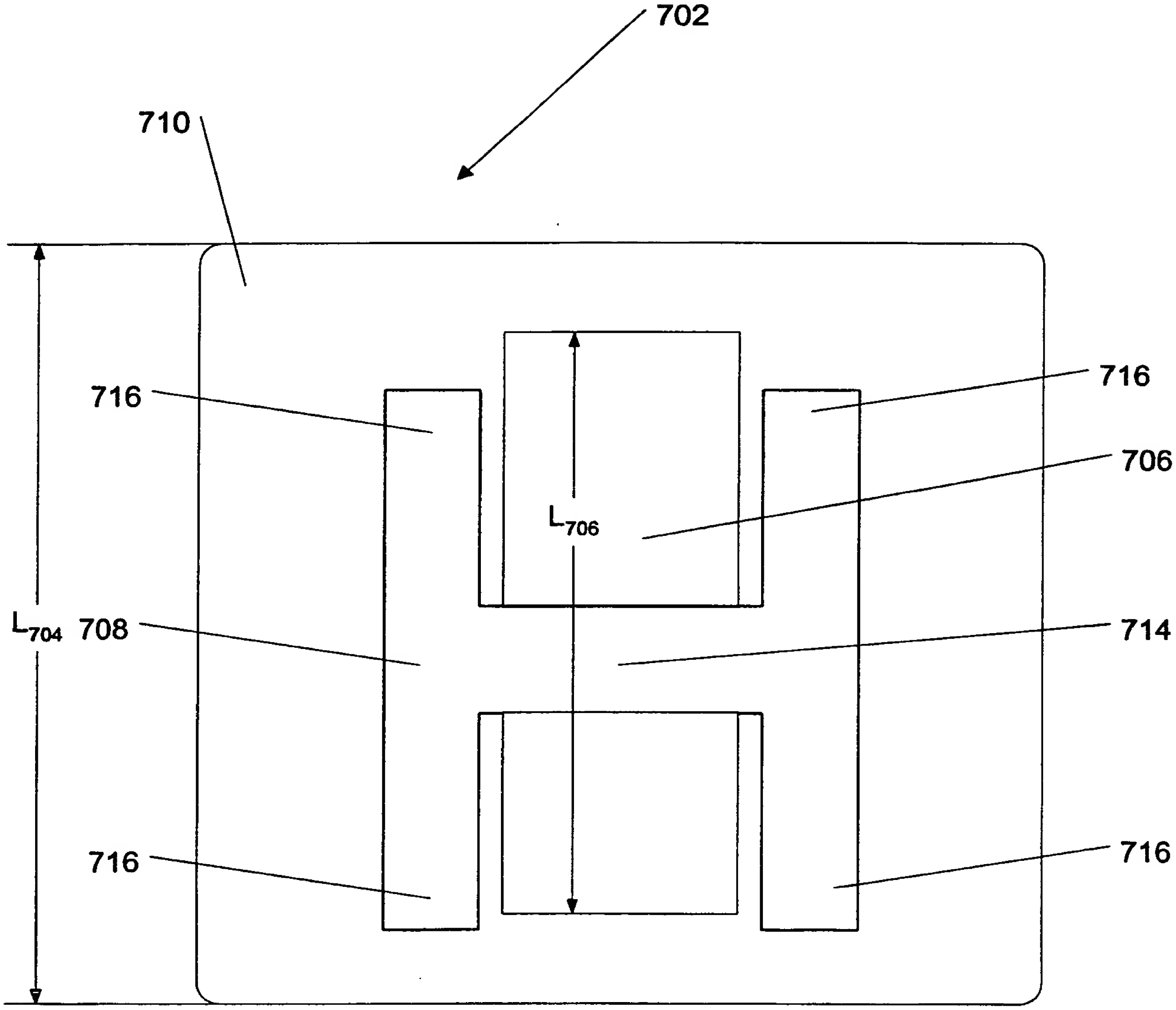

FIGURE 15K

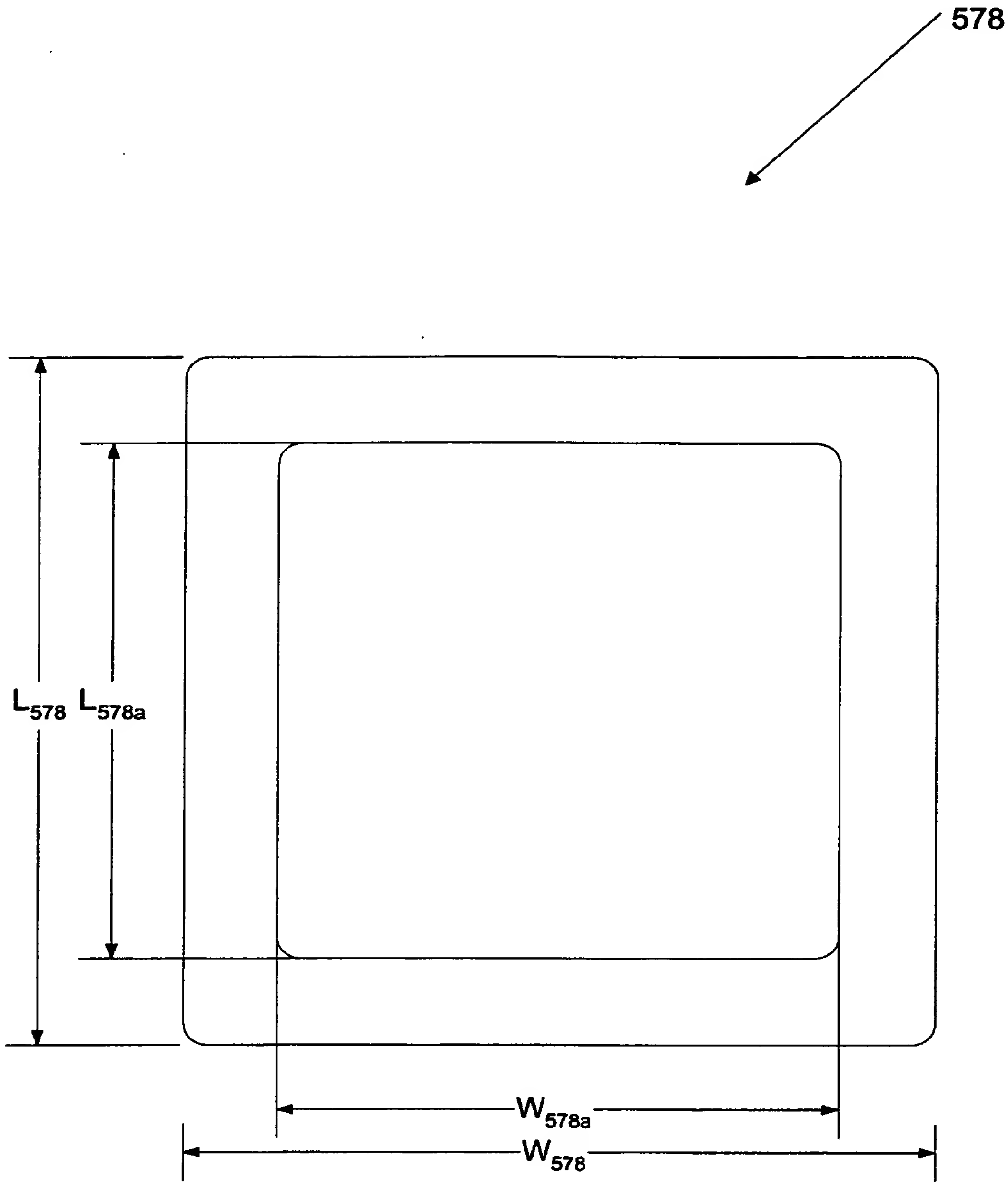

FIGURE 15L

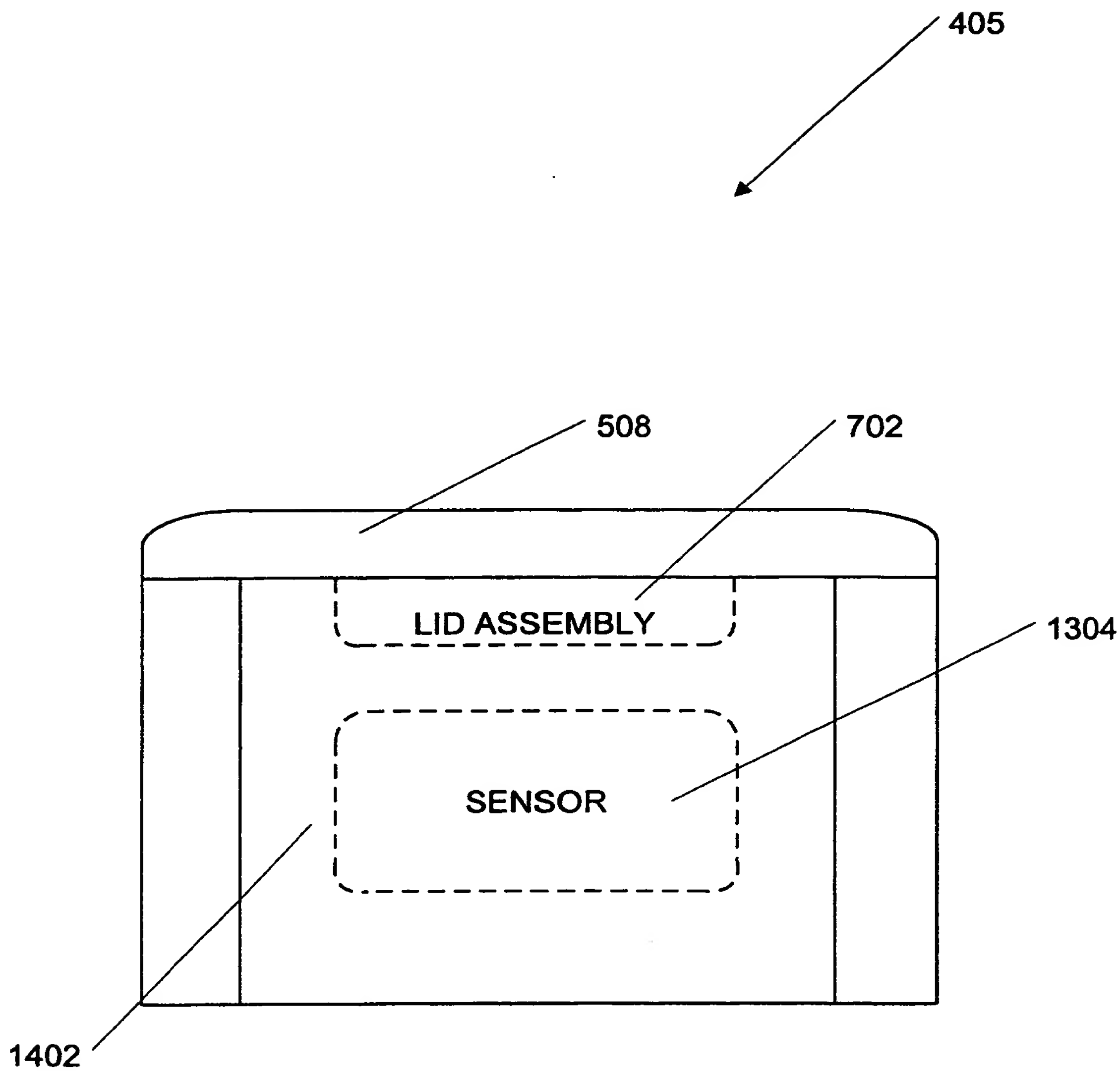

FIGURE 16A

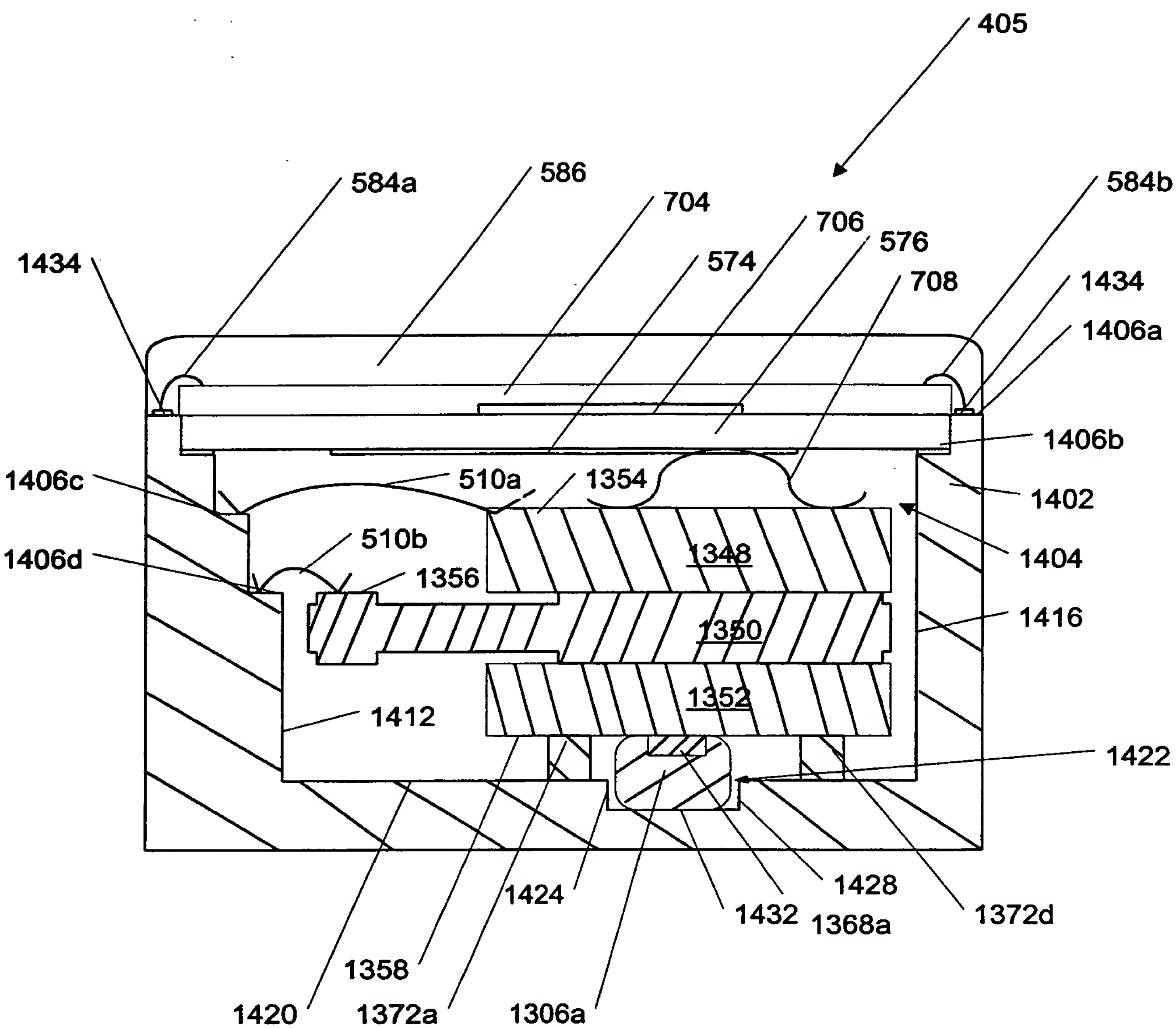
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FIGURE 16B

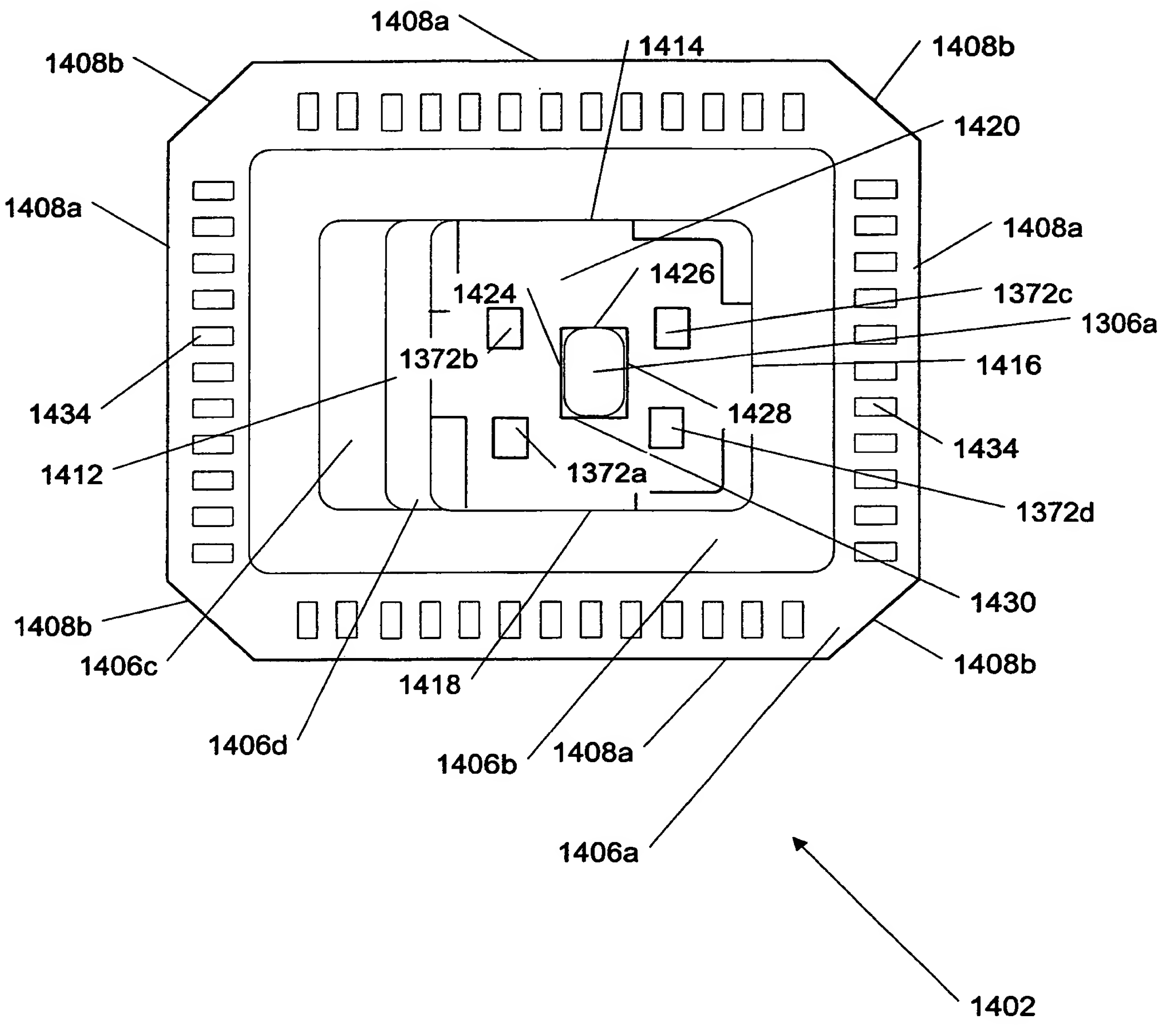
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FIGURE 16C

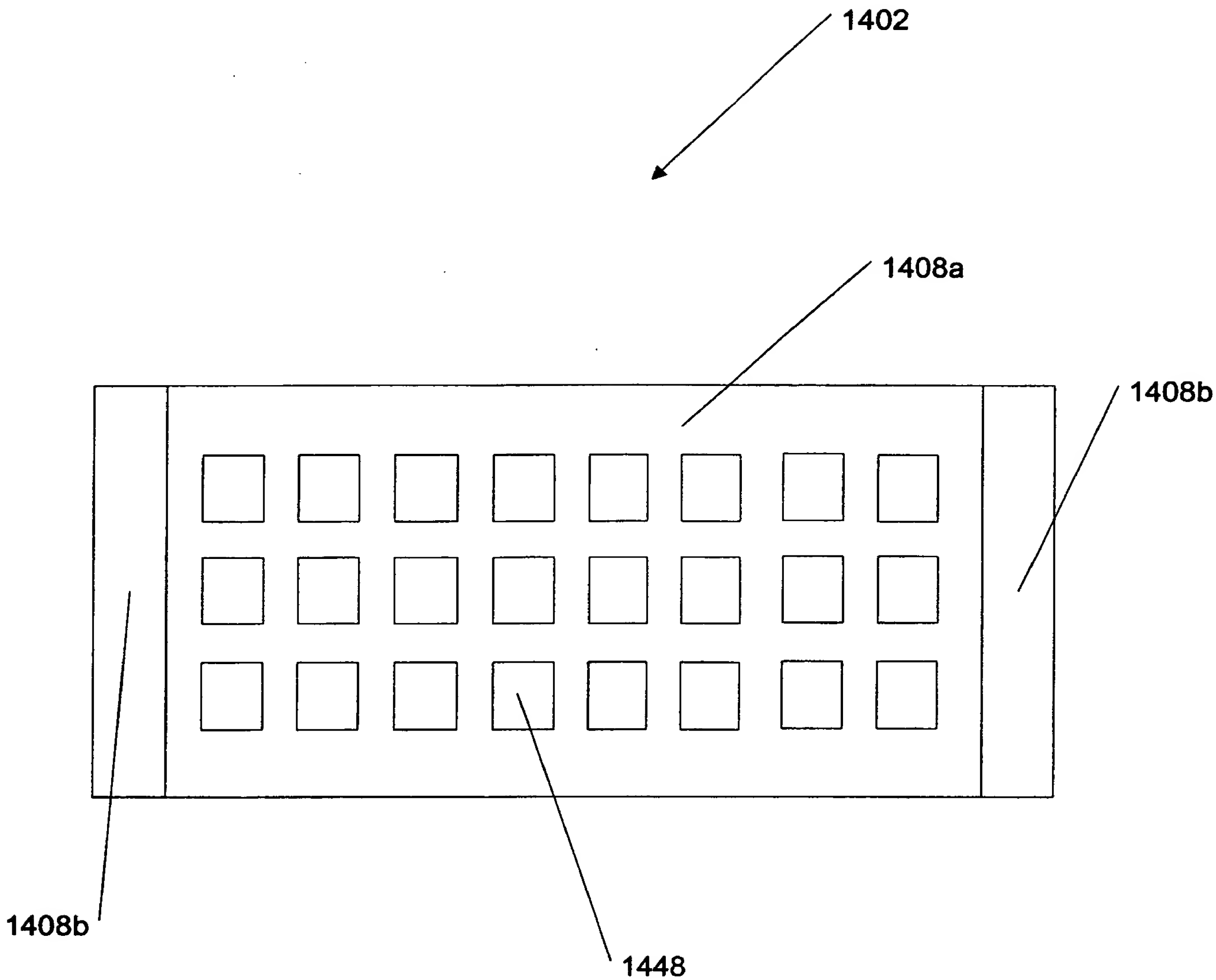

FIGURE 16D

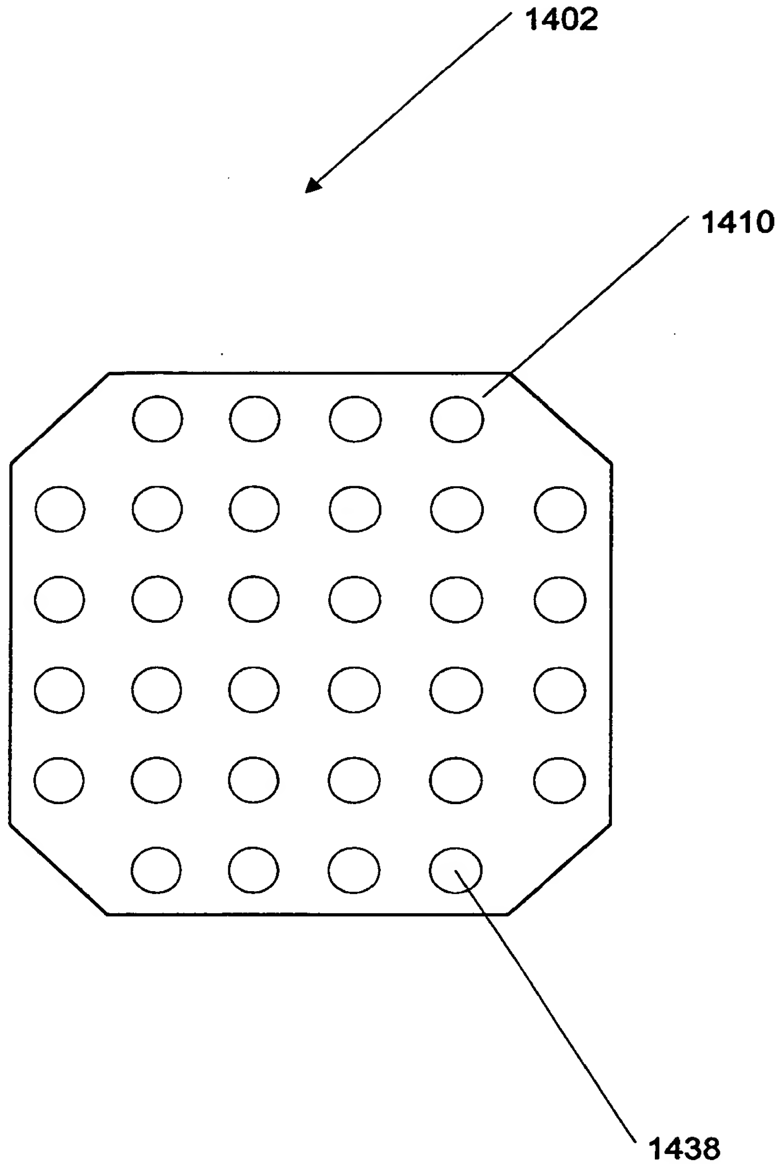

FIGURE 16E

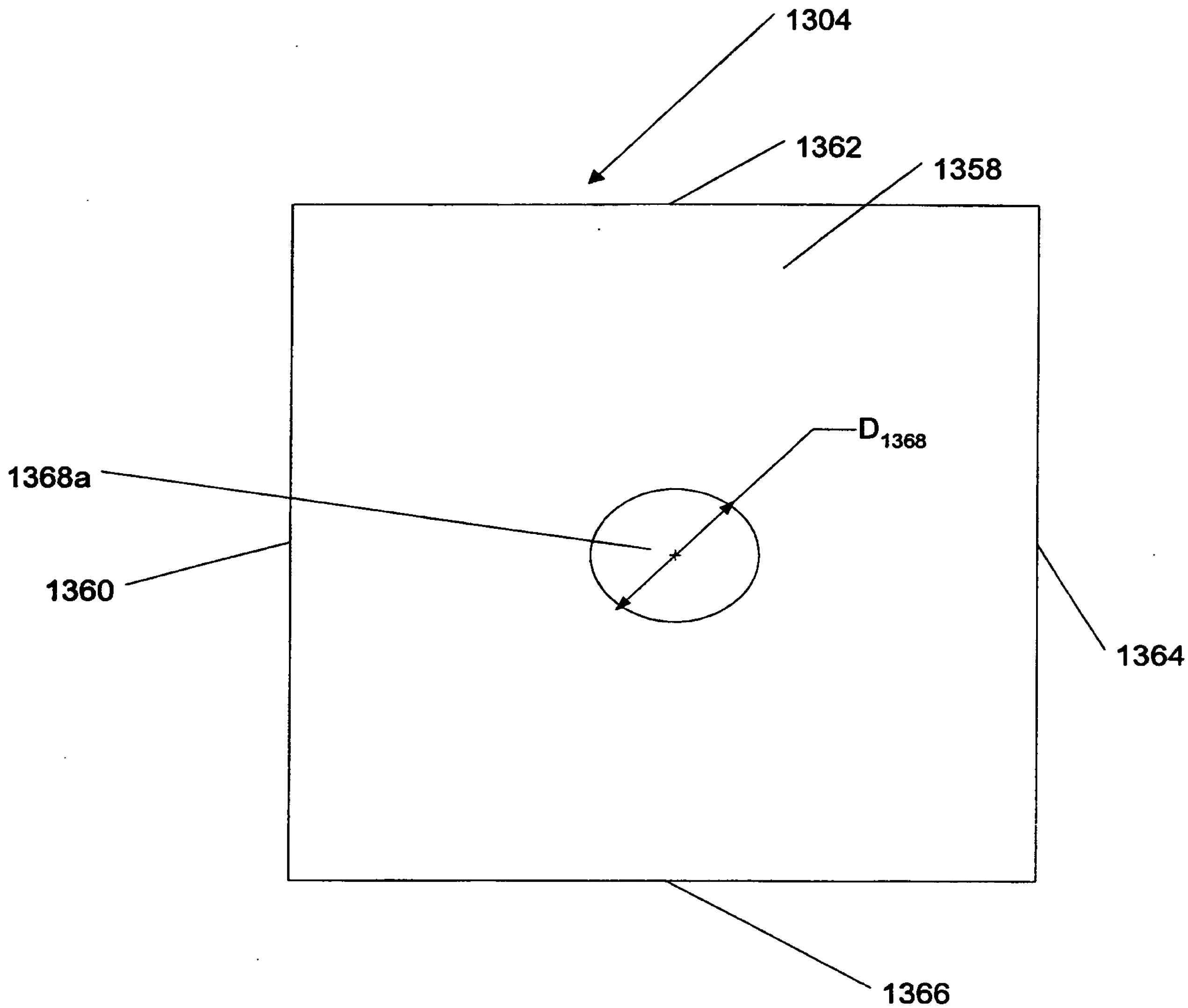

FIGURE 16F

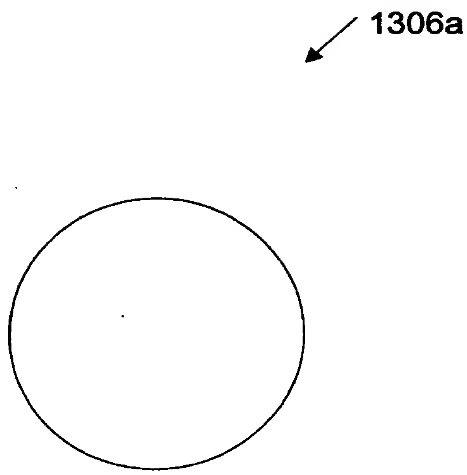

FIGURE 16G

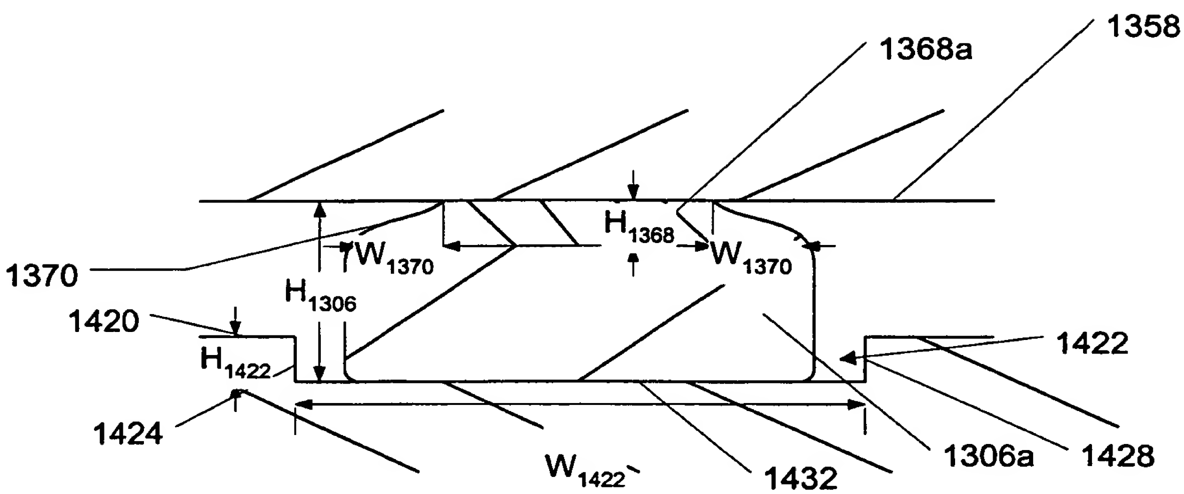

FIGURE 16H

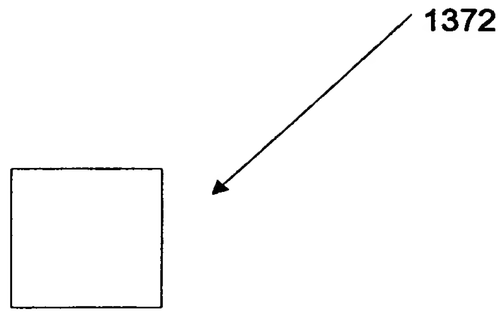

FIGURE 16I

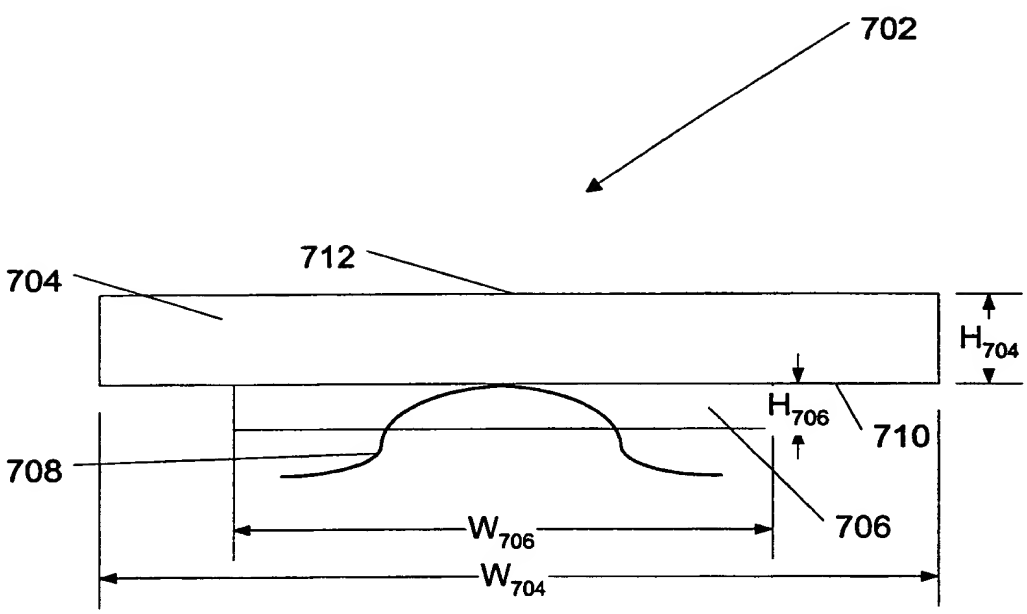

FIGURE 16J

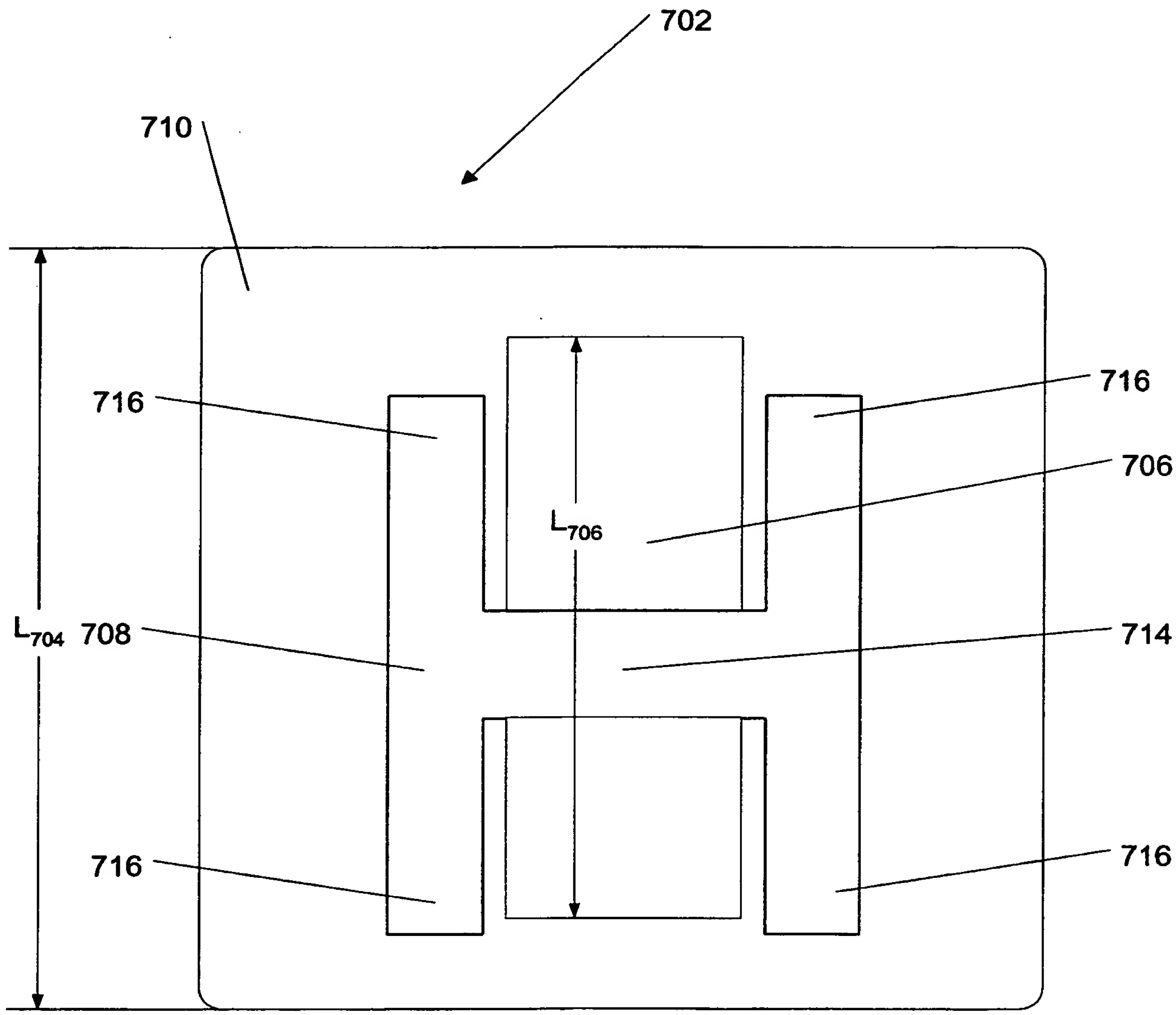

FIGURE 16K

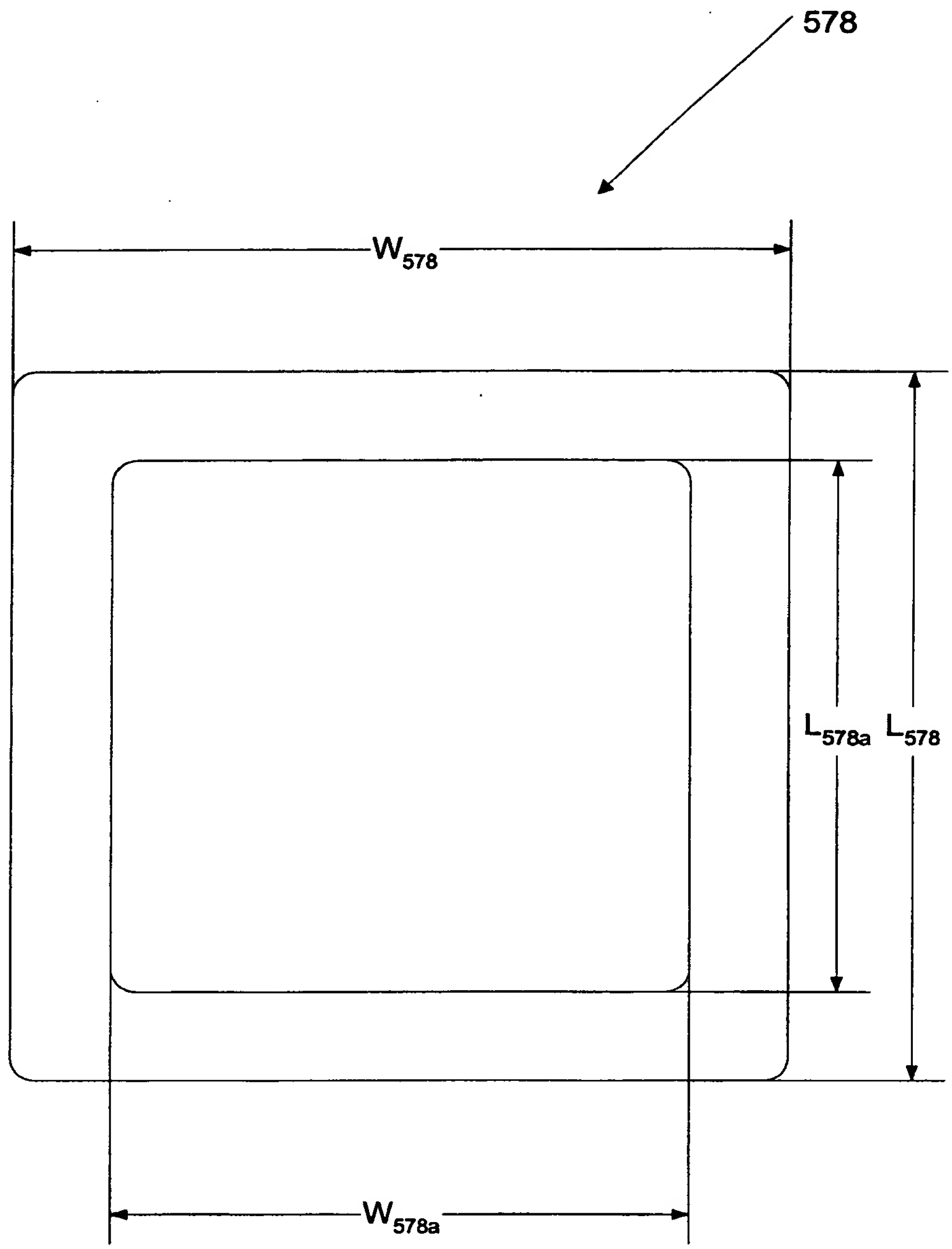

FIGURE 16L

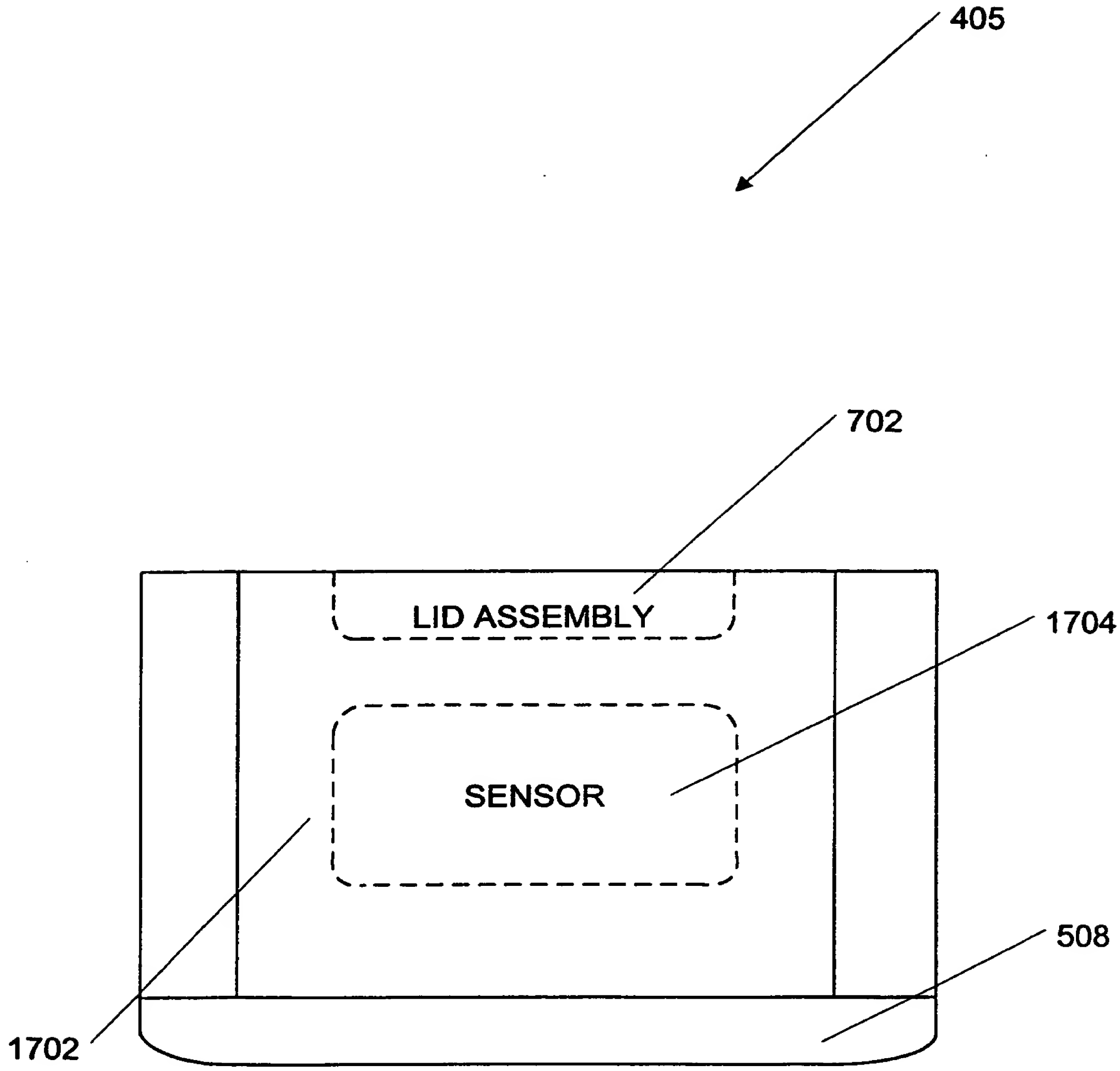

FIGURE 17A

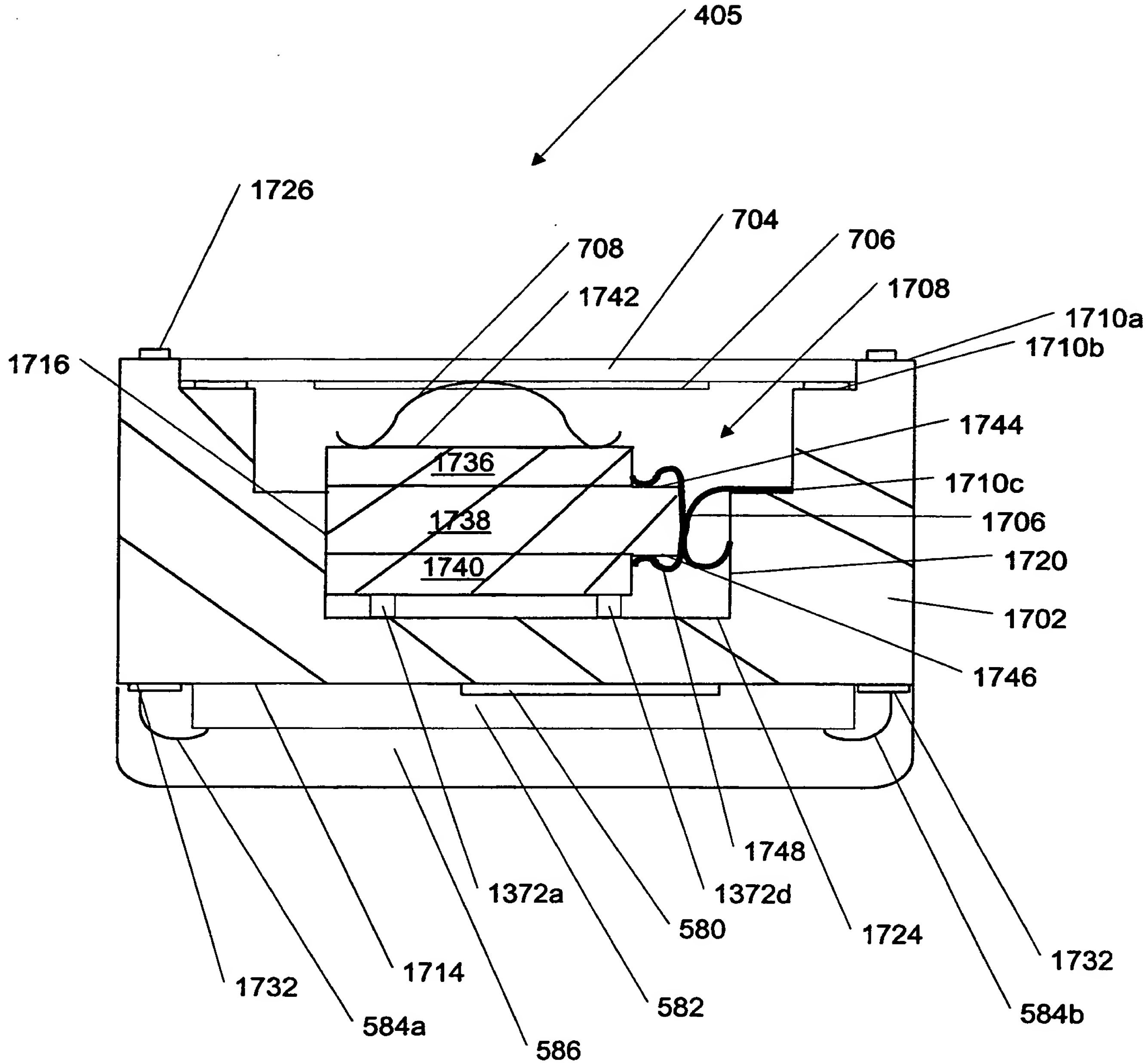
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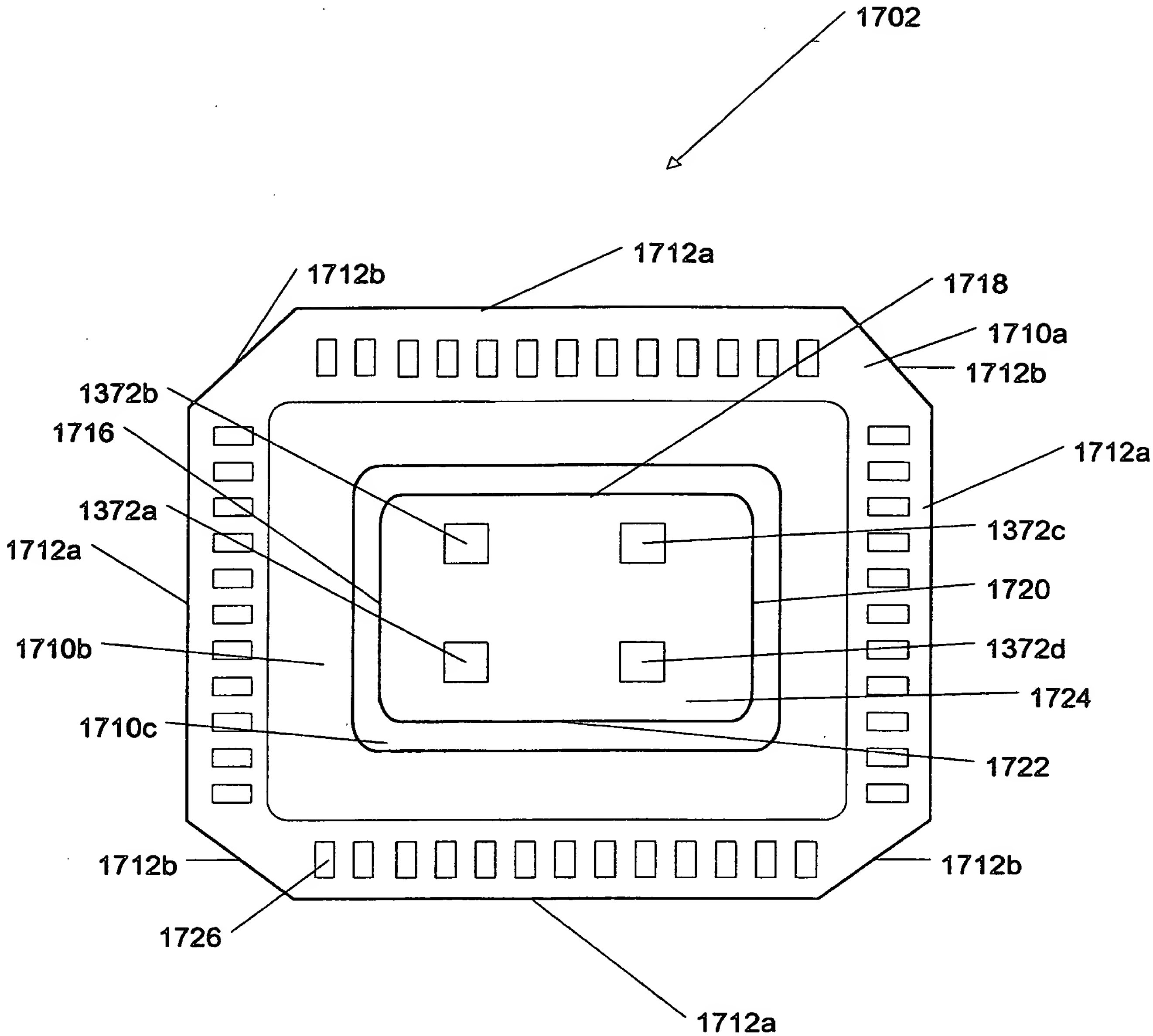
FIGURE 17B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1712b
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1712a

FIGURE 17C

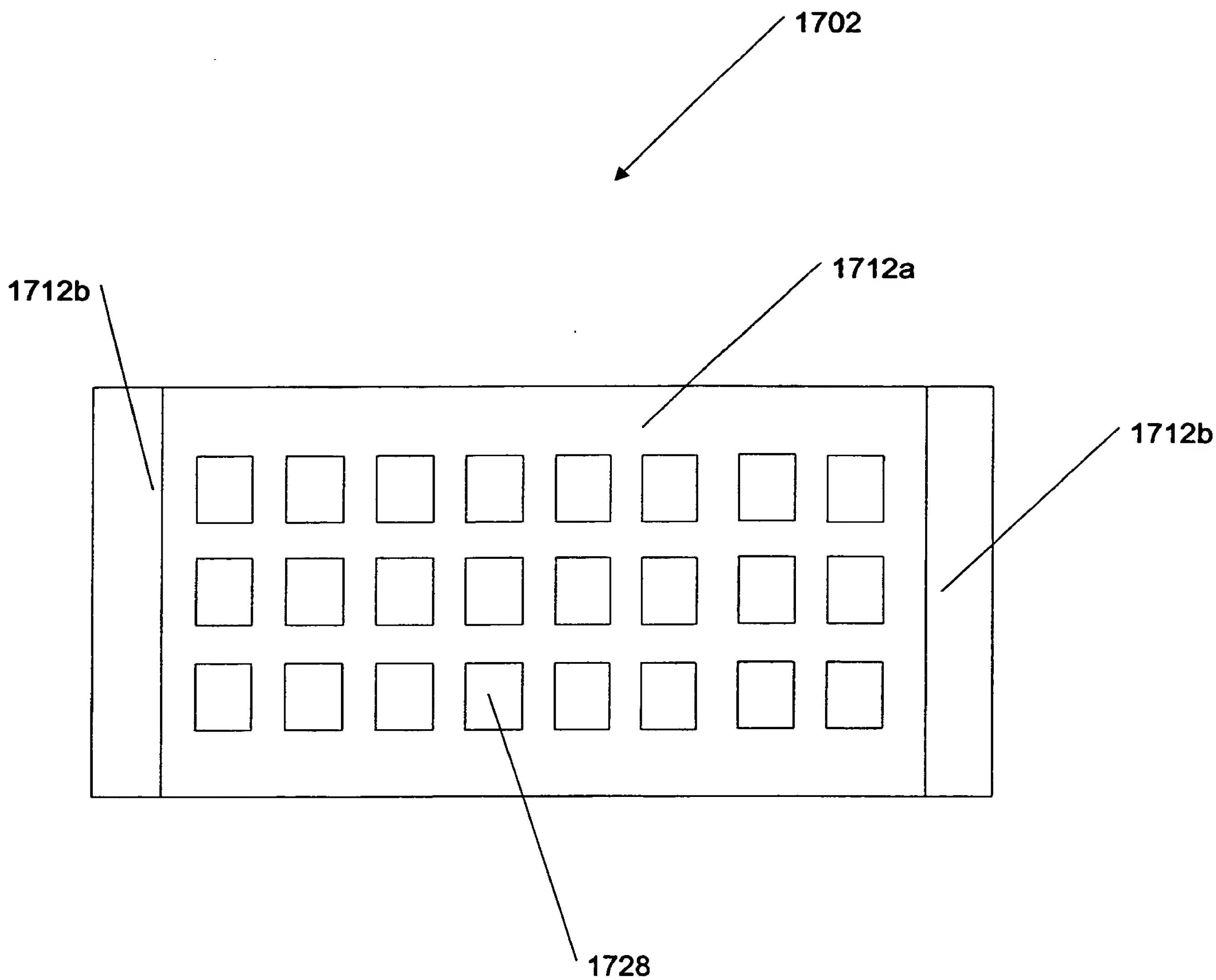

FIGURE 17D

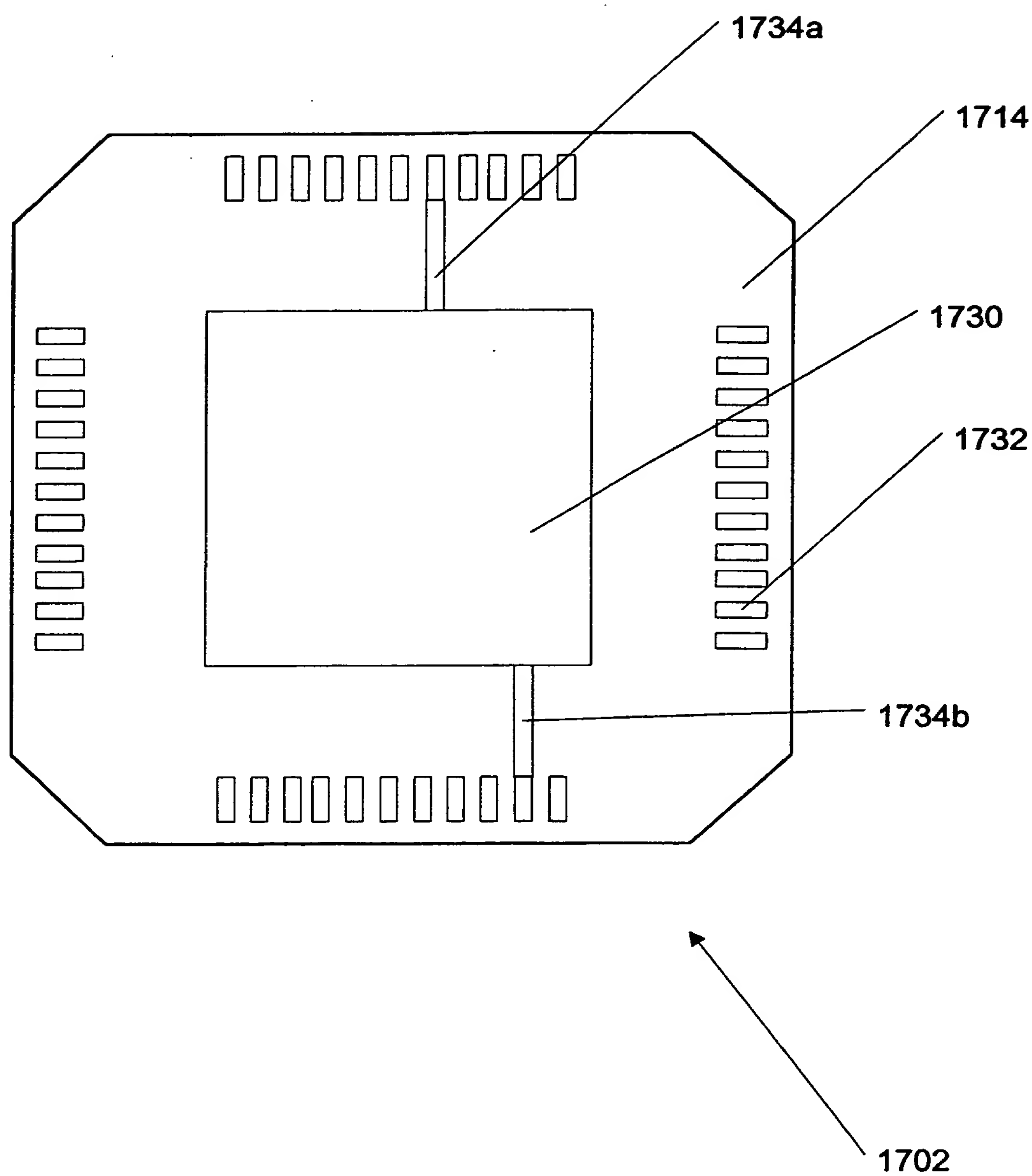

FIGURE 17E

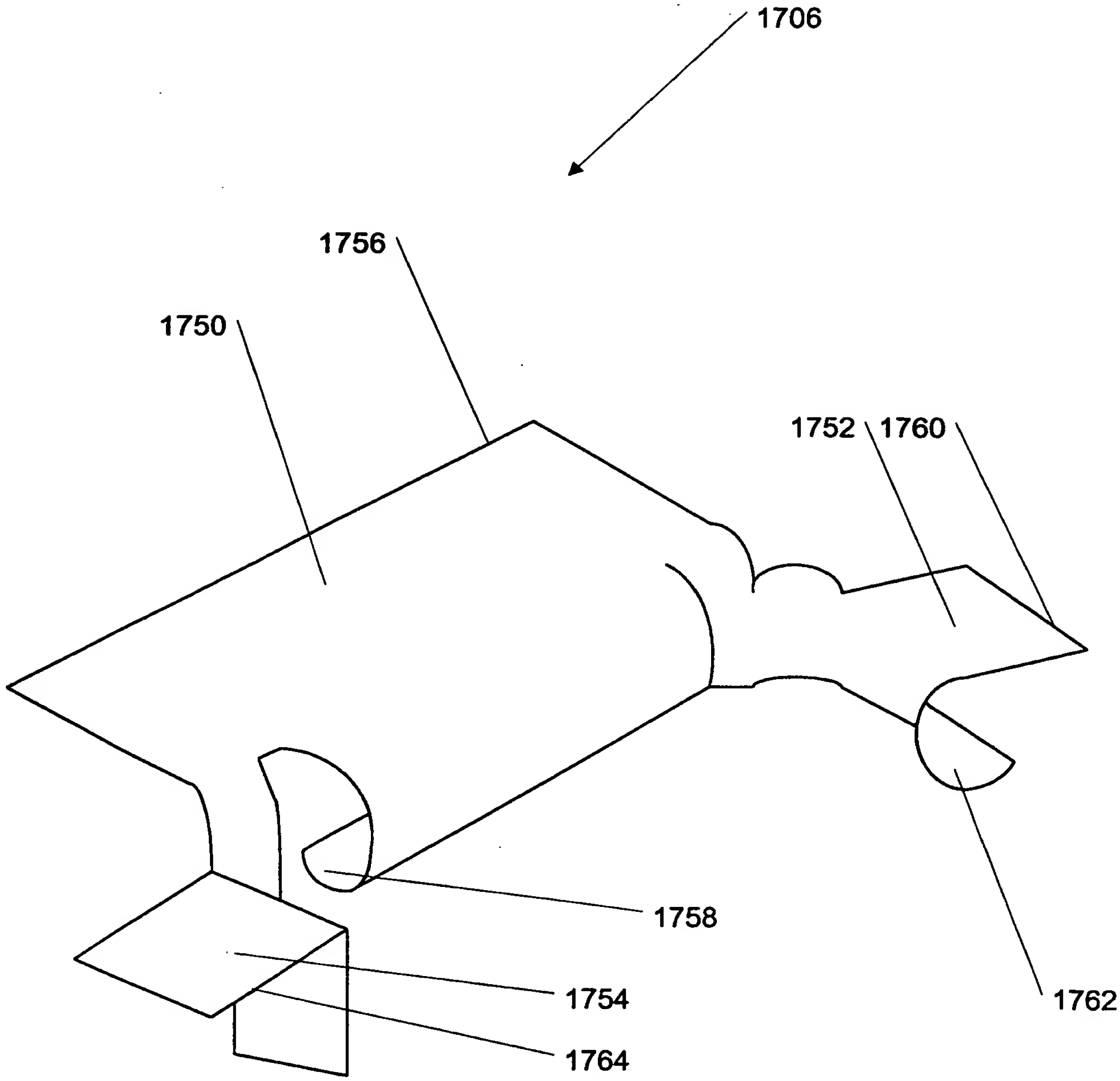

FIGURE 17F

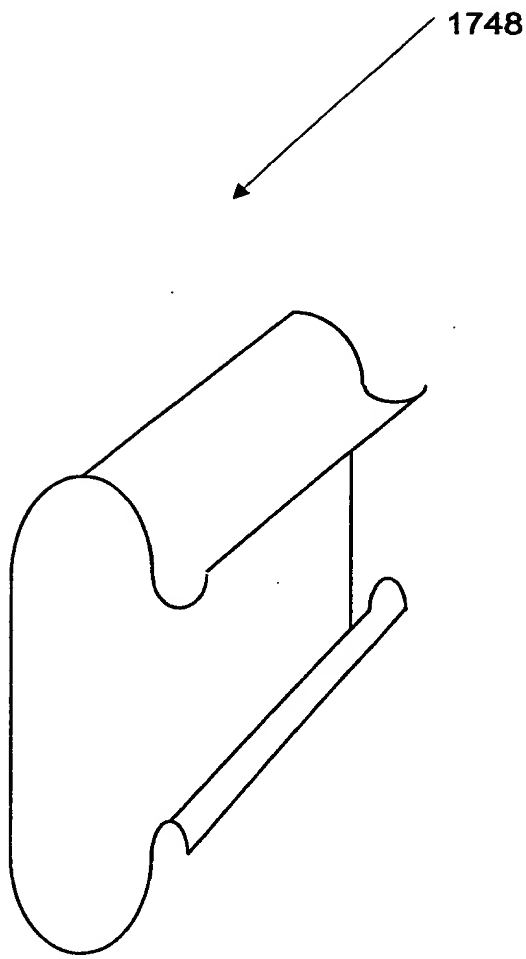

FIGURE 17G

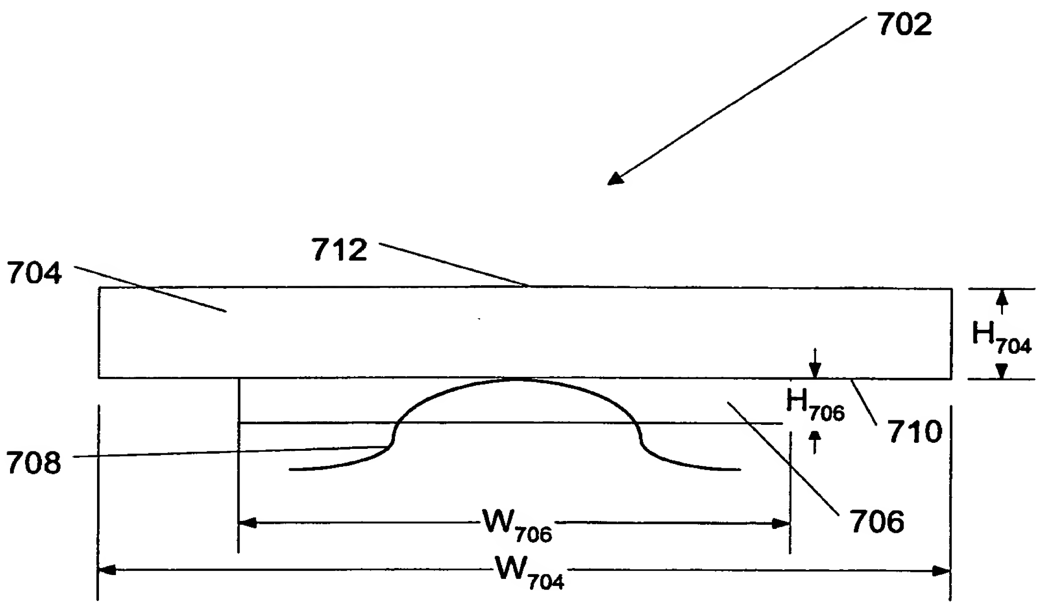

FIGURE 17H

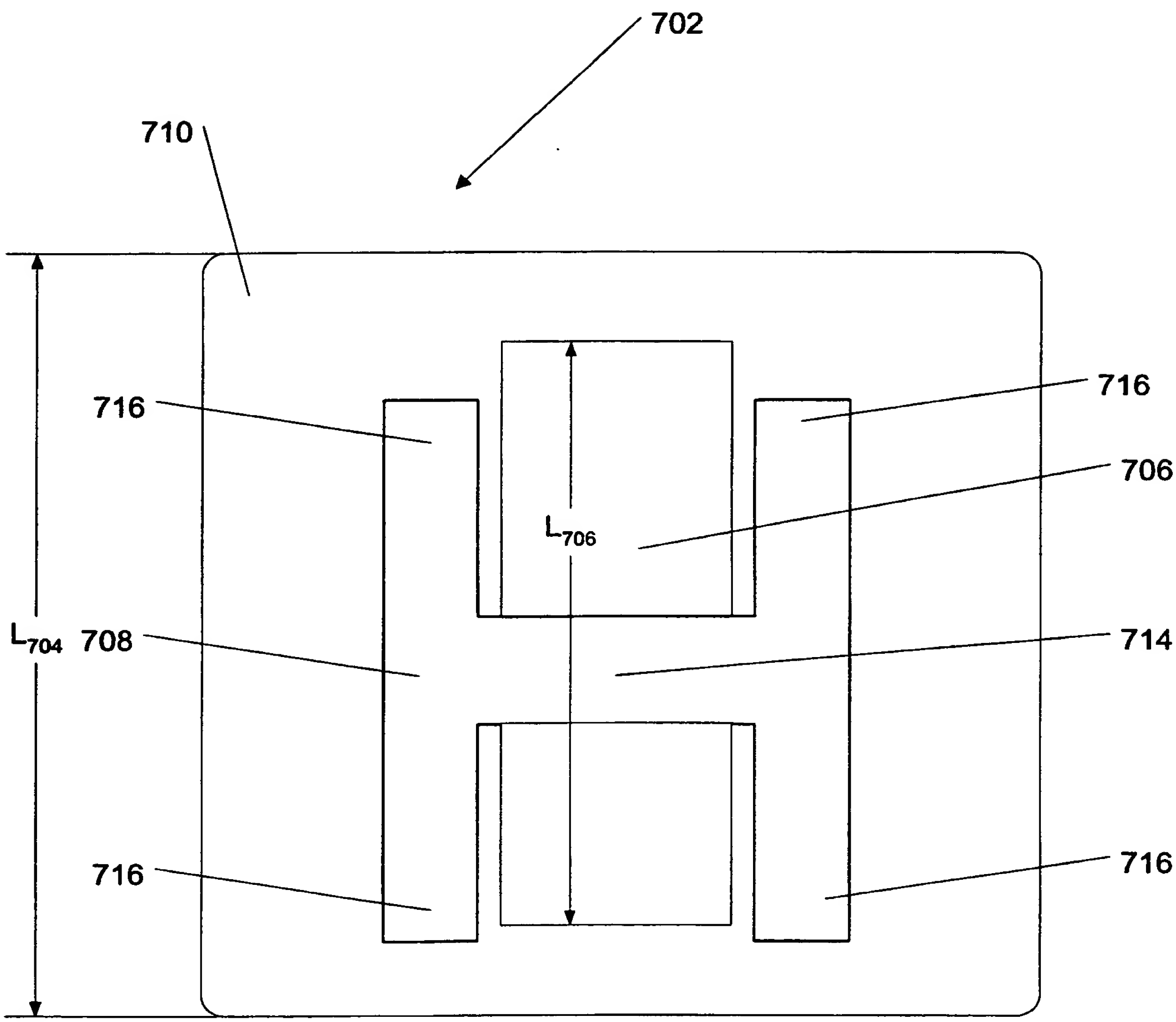

FIGURE 17I

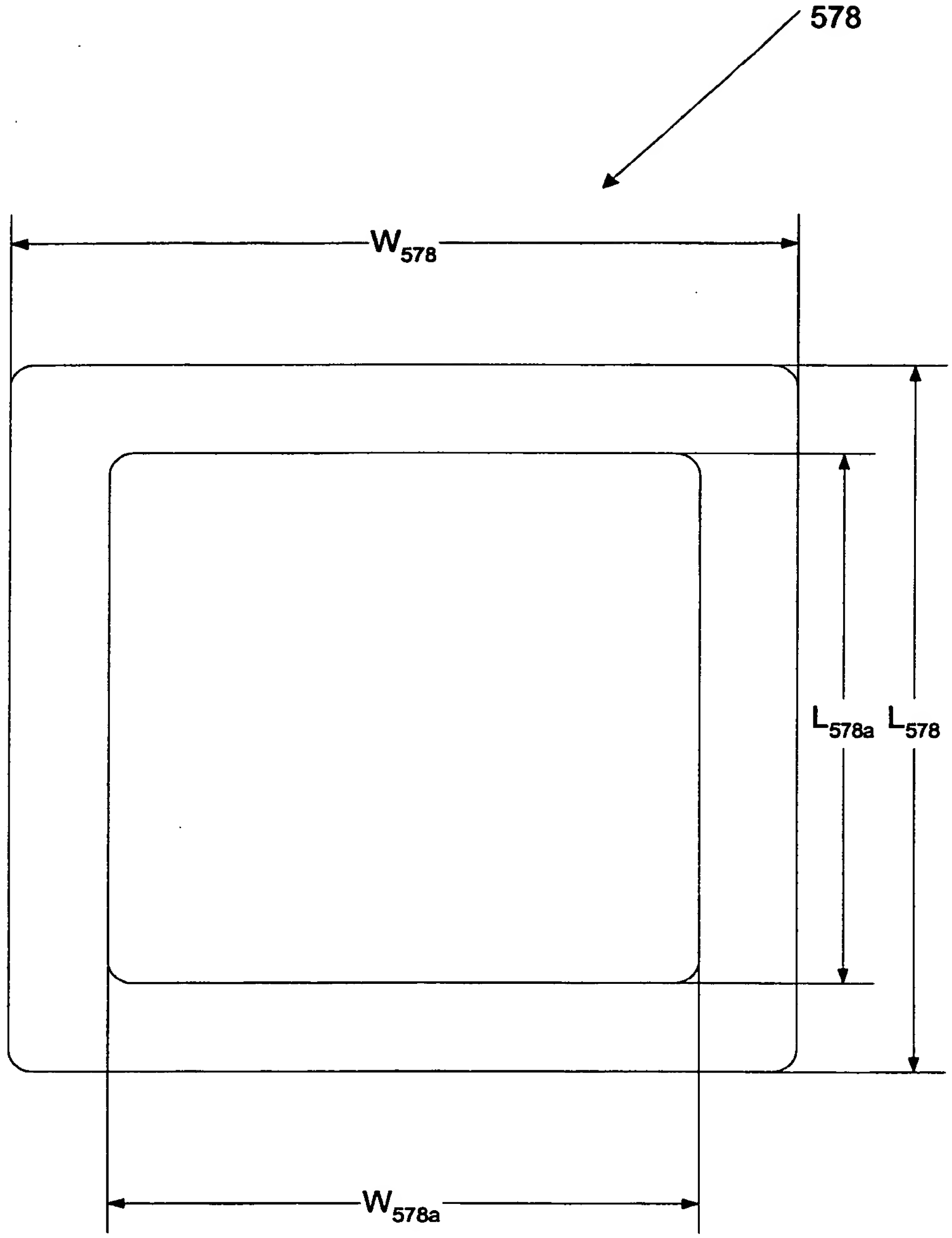

FIGURE 17J

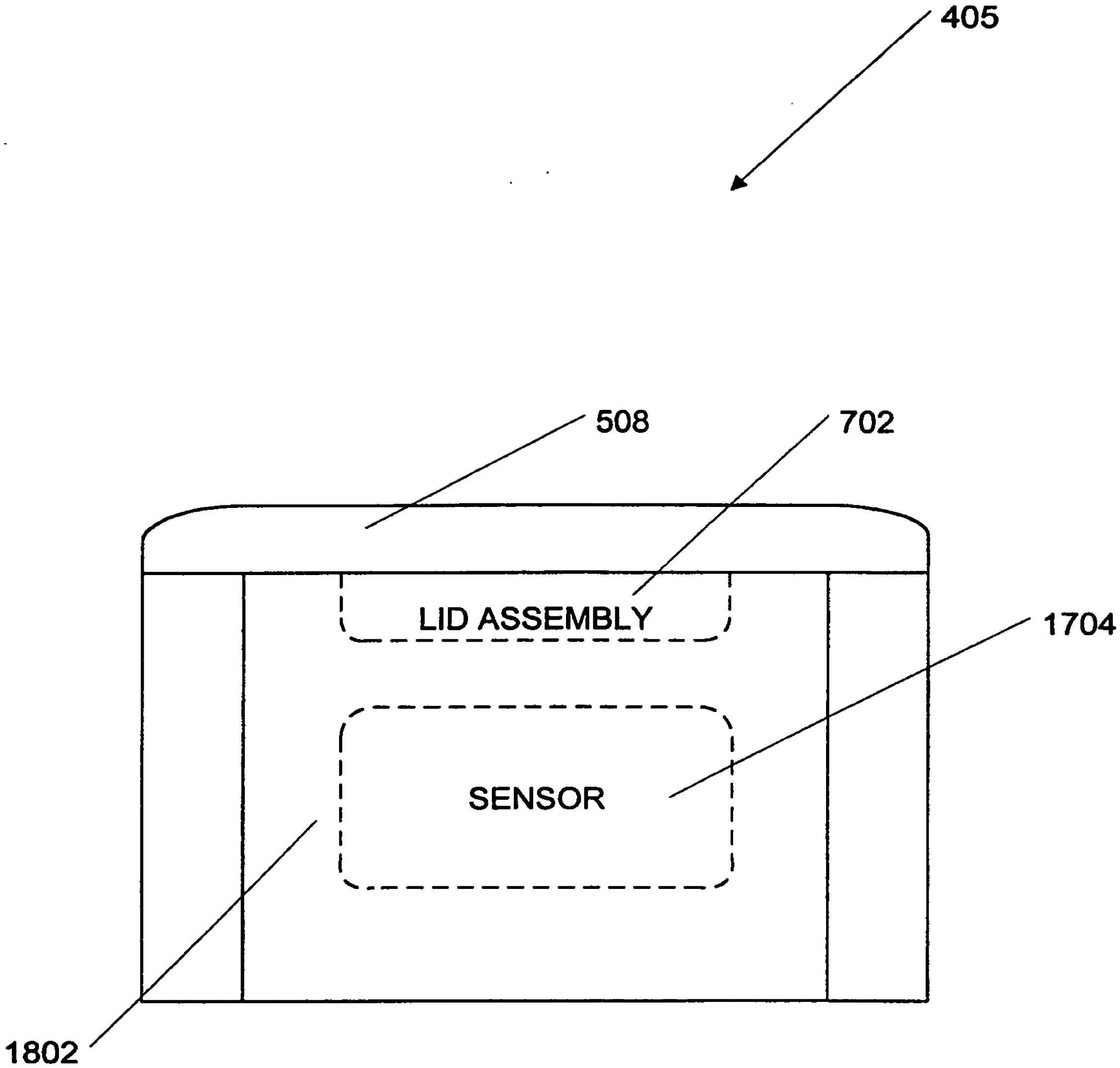

FIGURE 18A

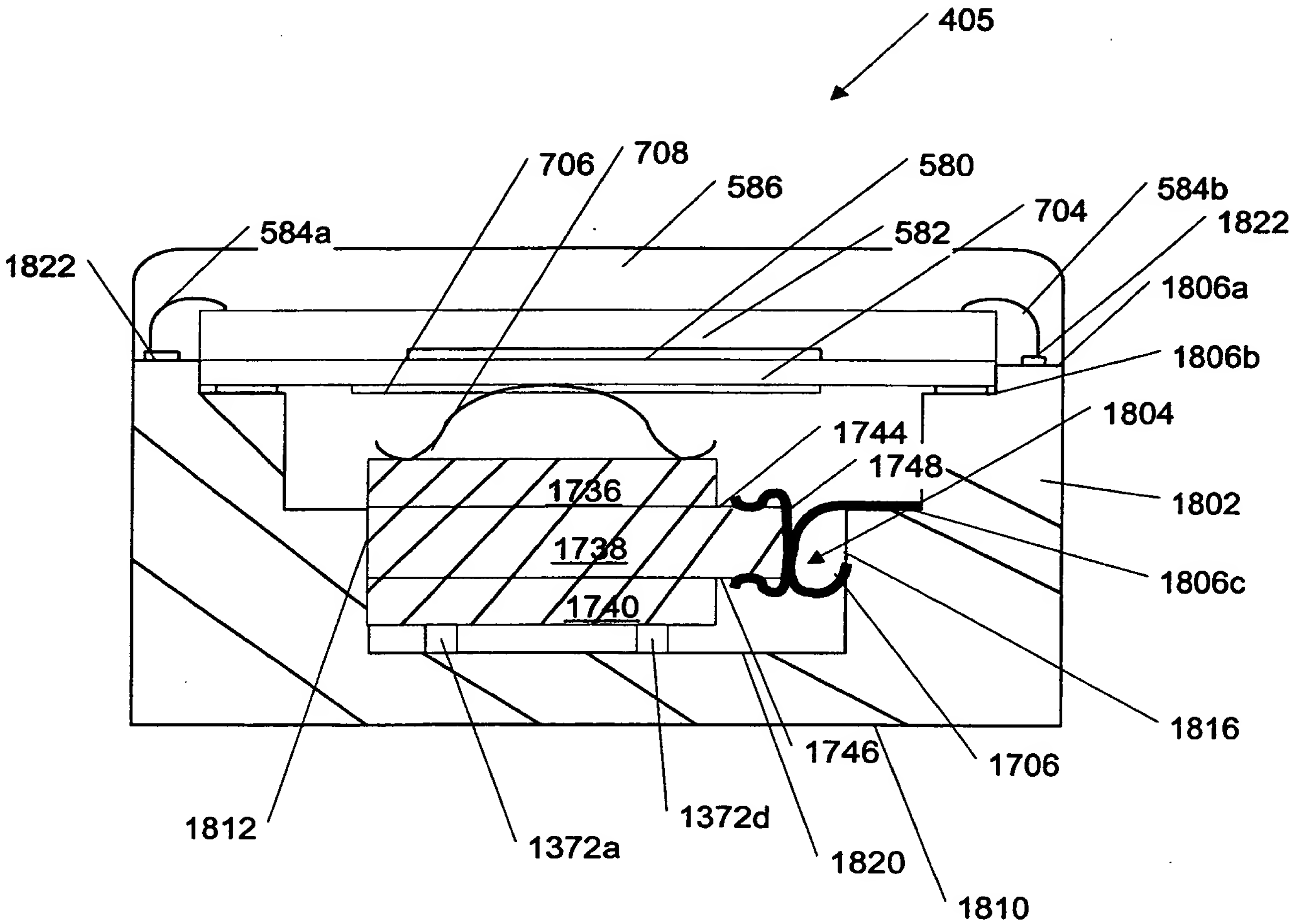
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FIGURE 18B

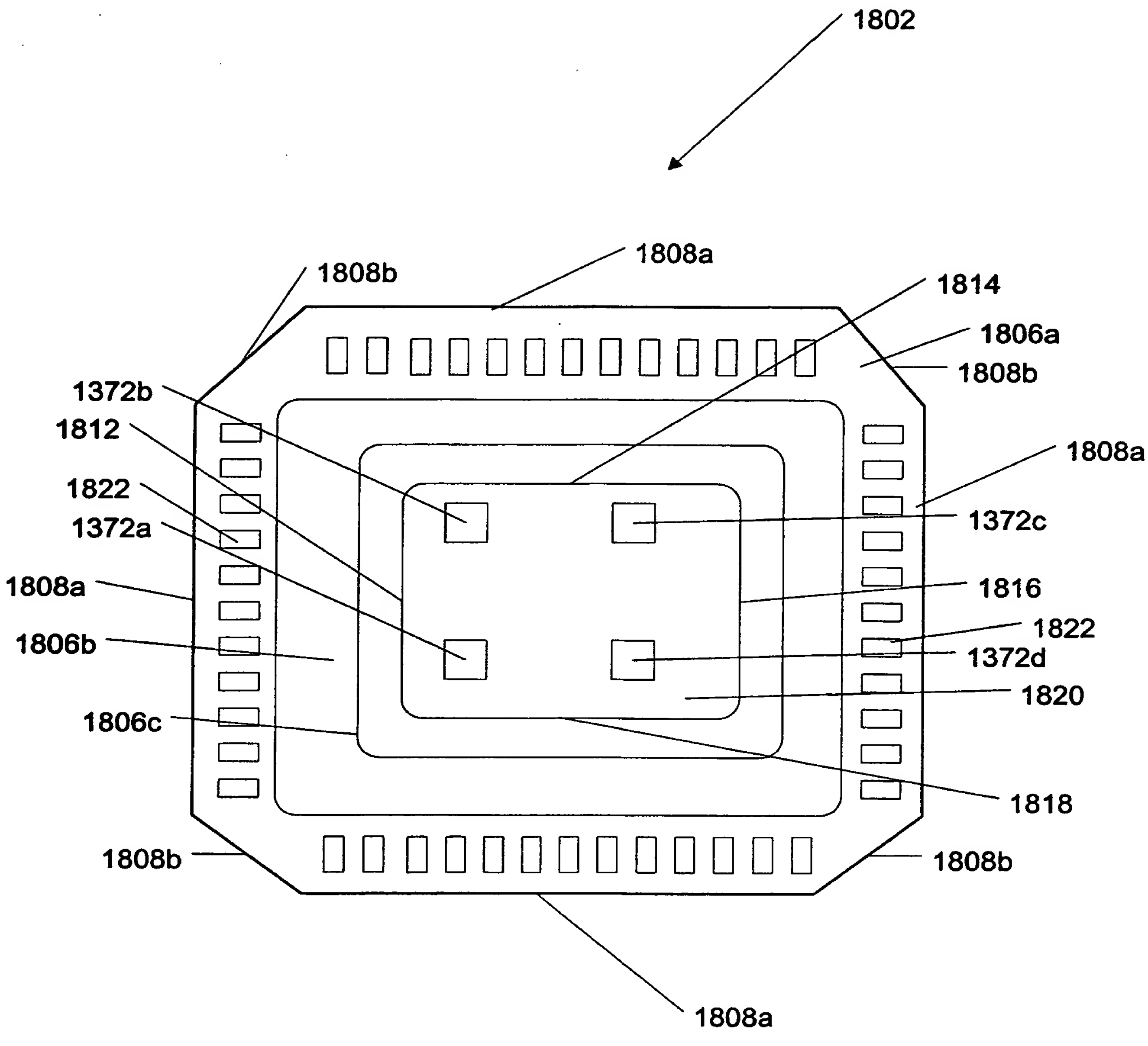
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FIGURE 18C

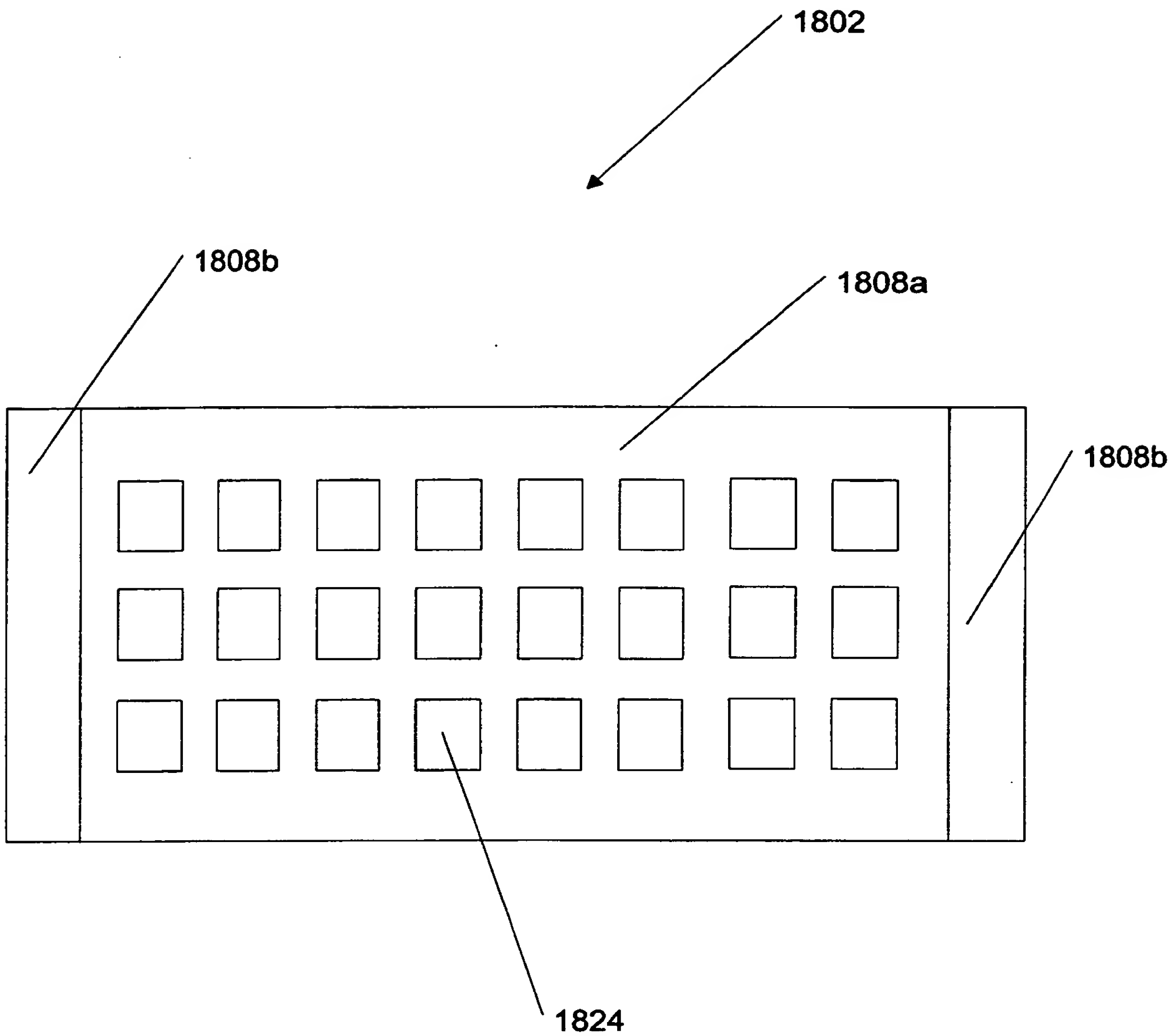

FIGURE18D

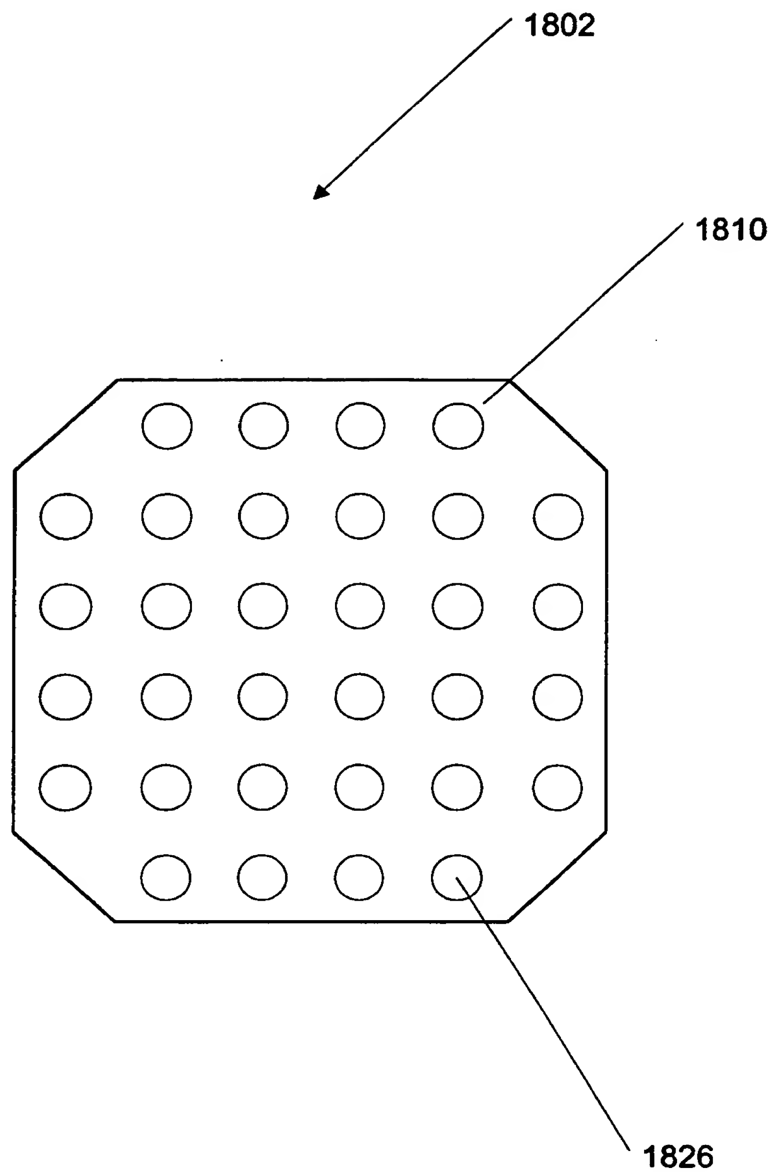

FIGURE 18E

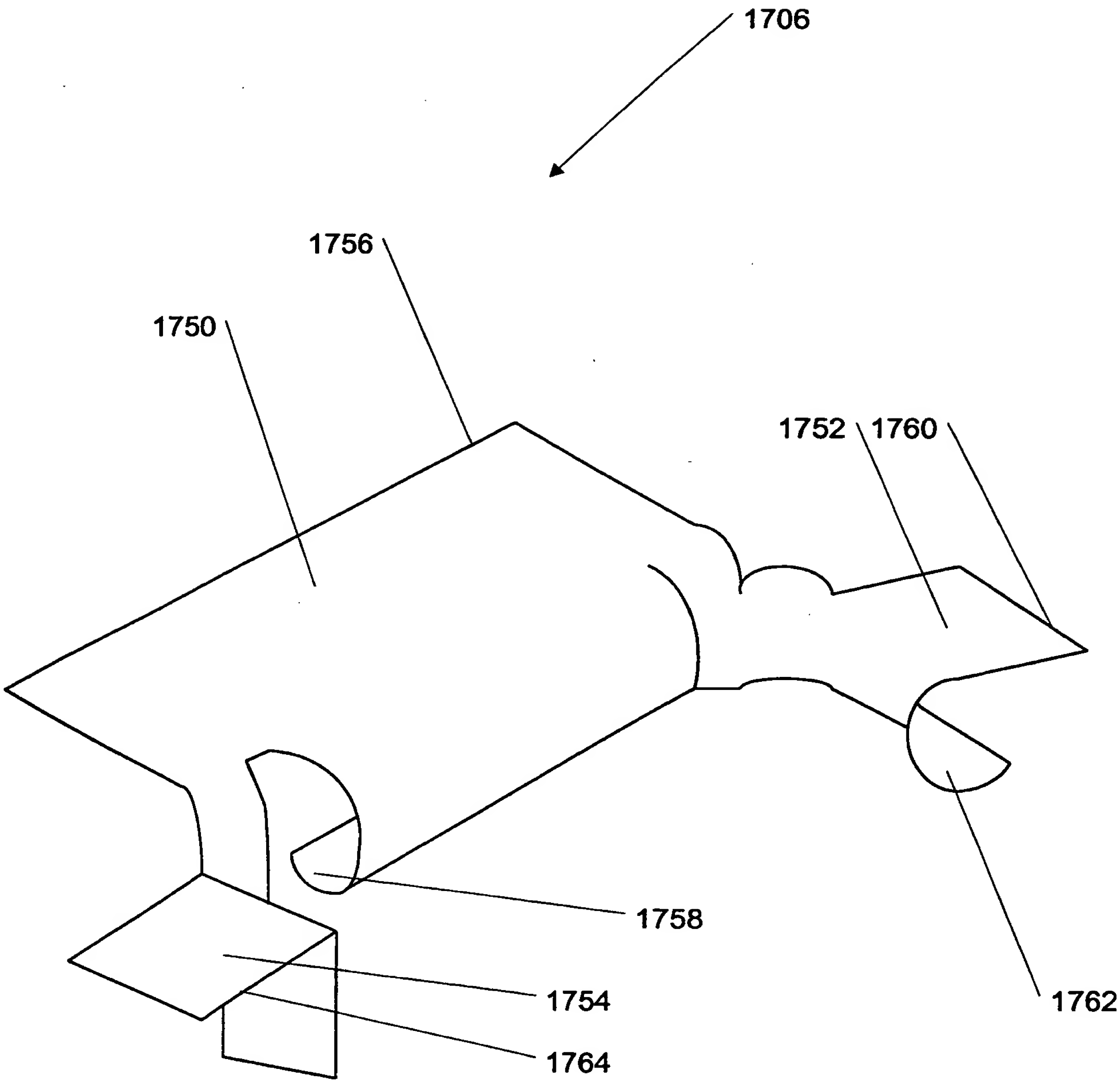

FIGURE 18F

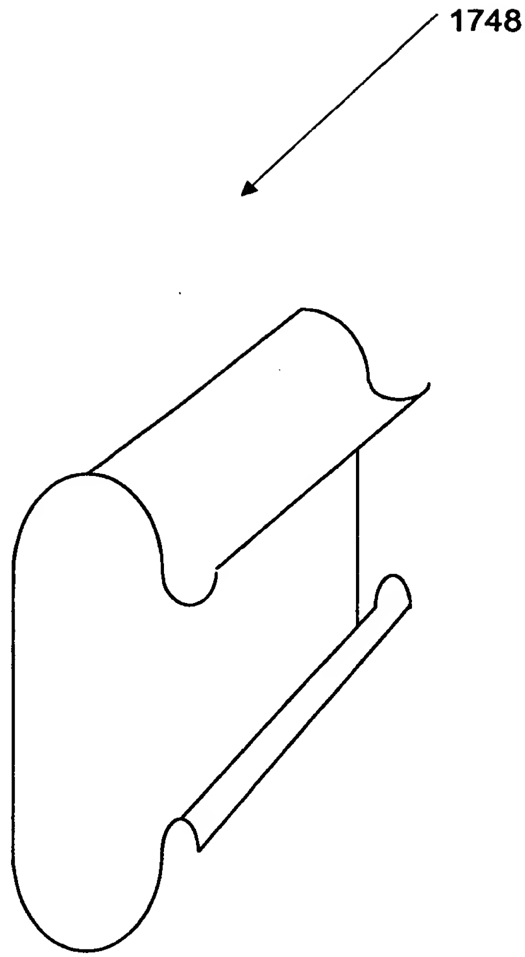

FIGURE 18G

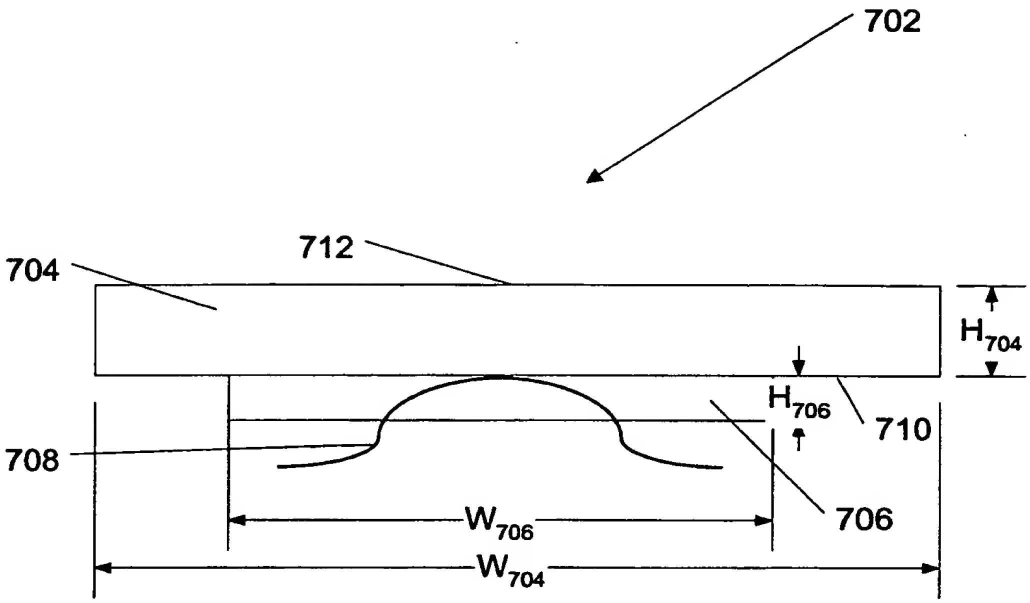

FIGURE 18H

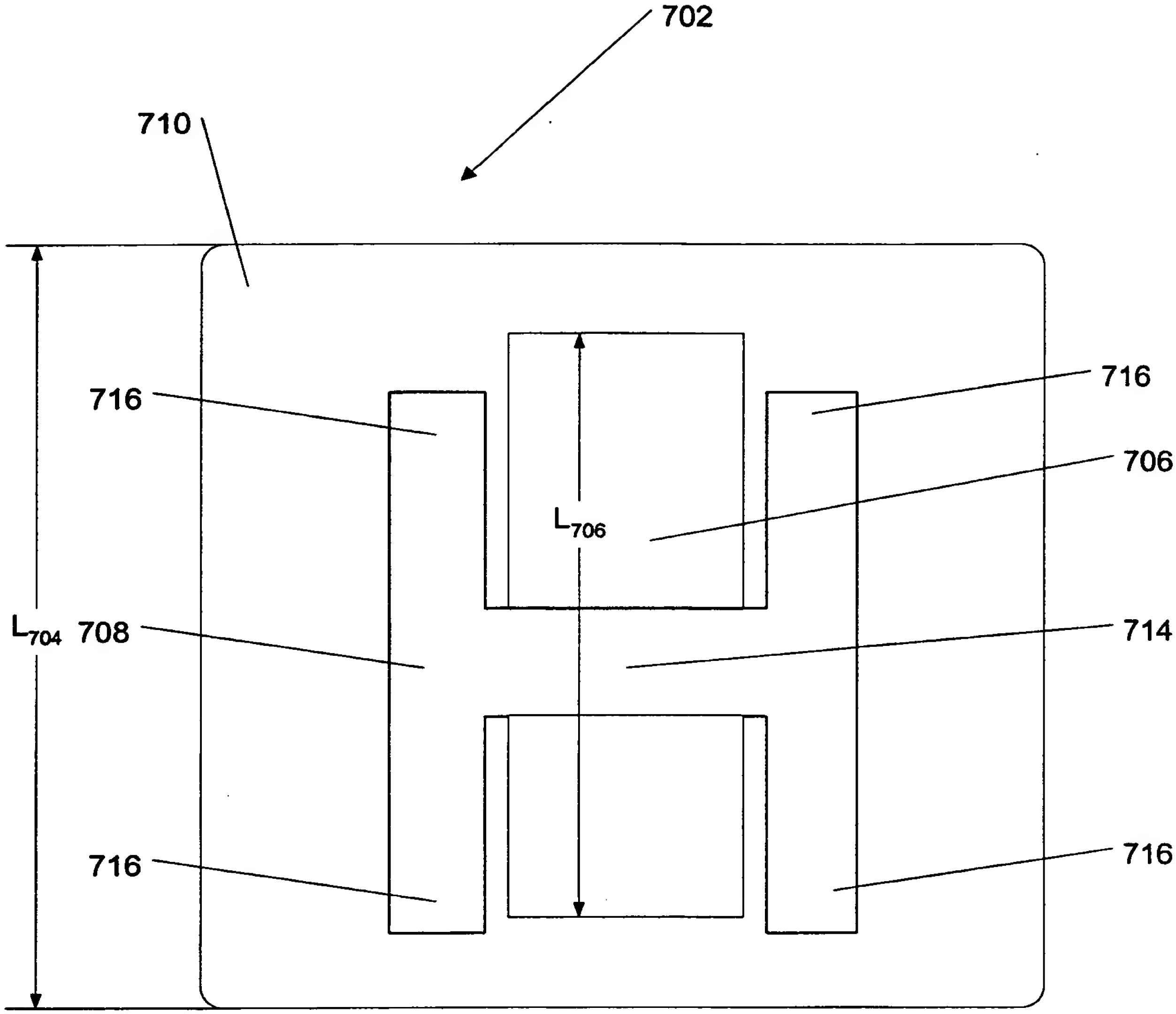

FIGURE 18I

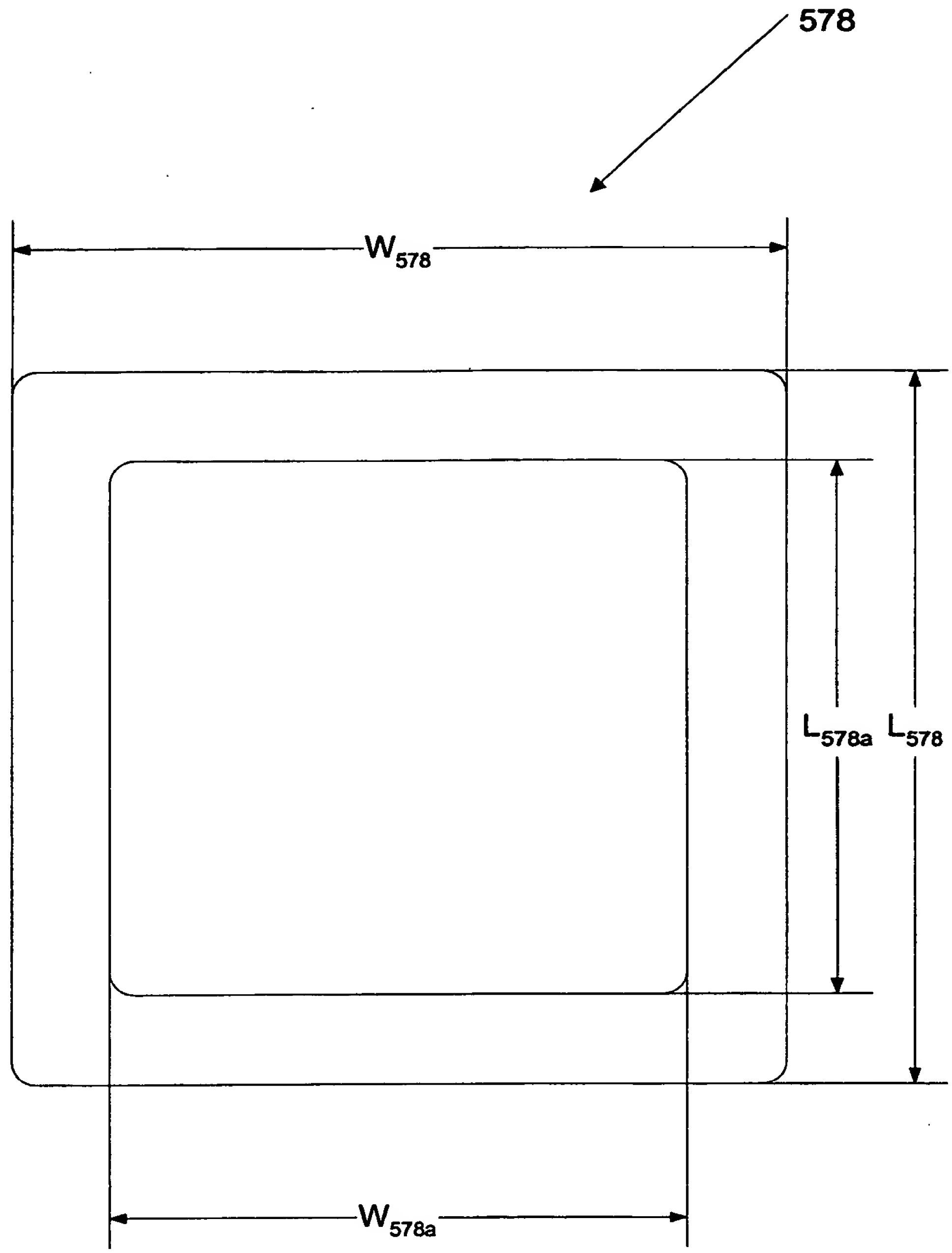

FIGURE 18J

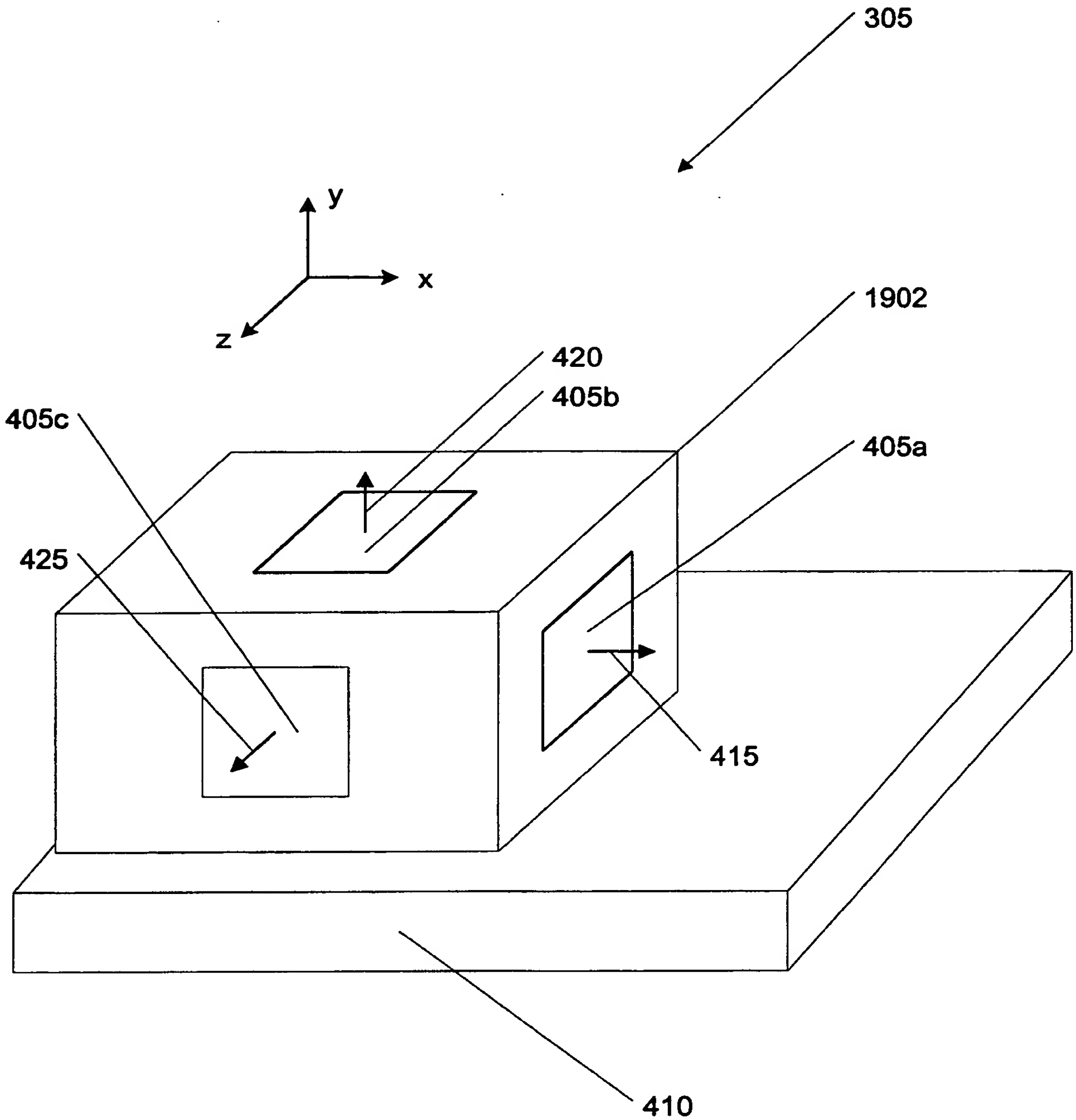

FIGURE 19

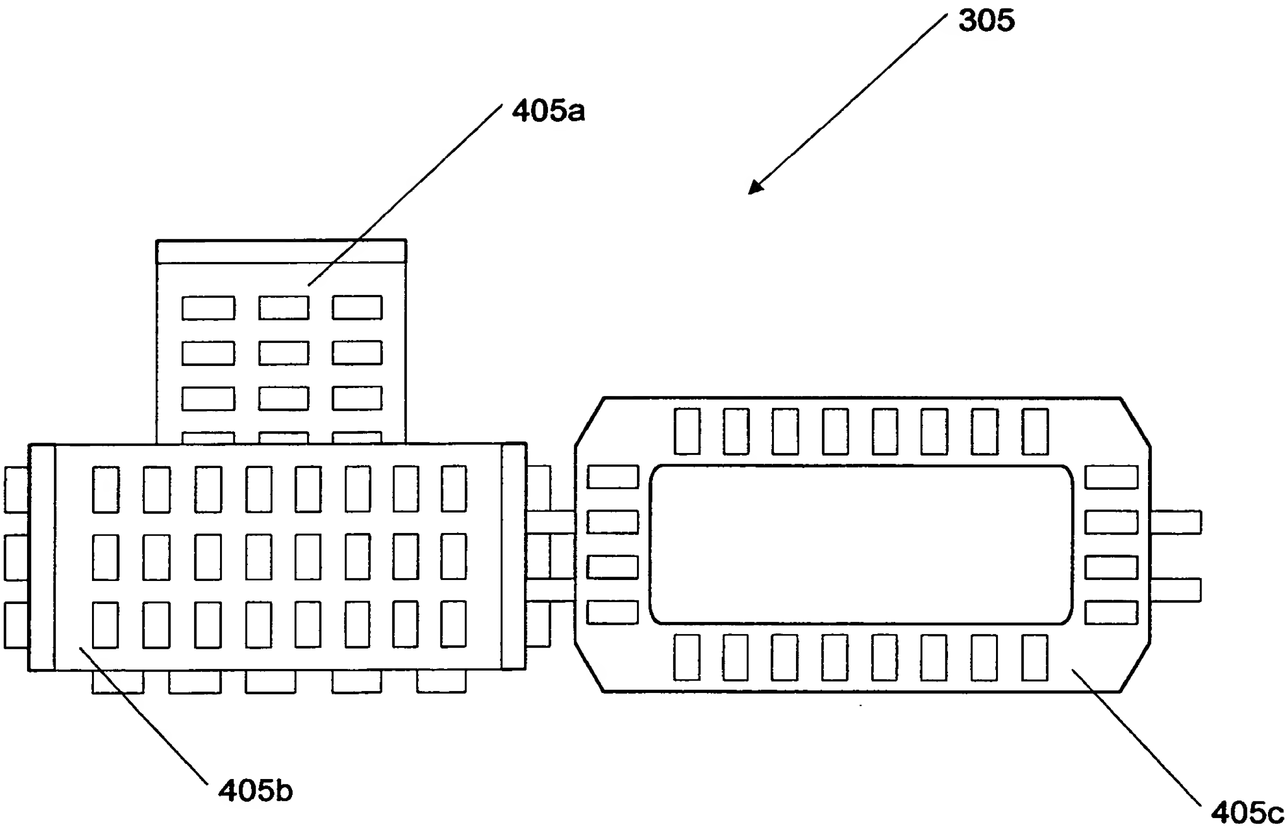

FIGURE 20

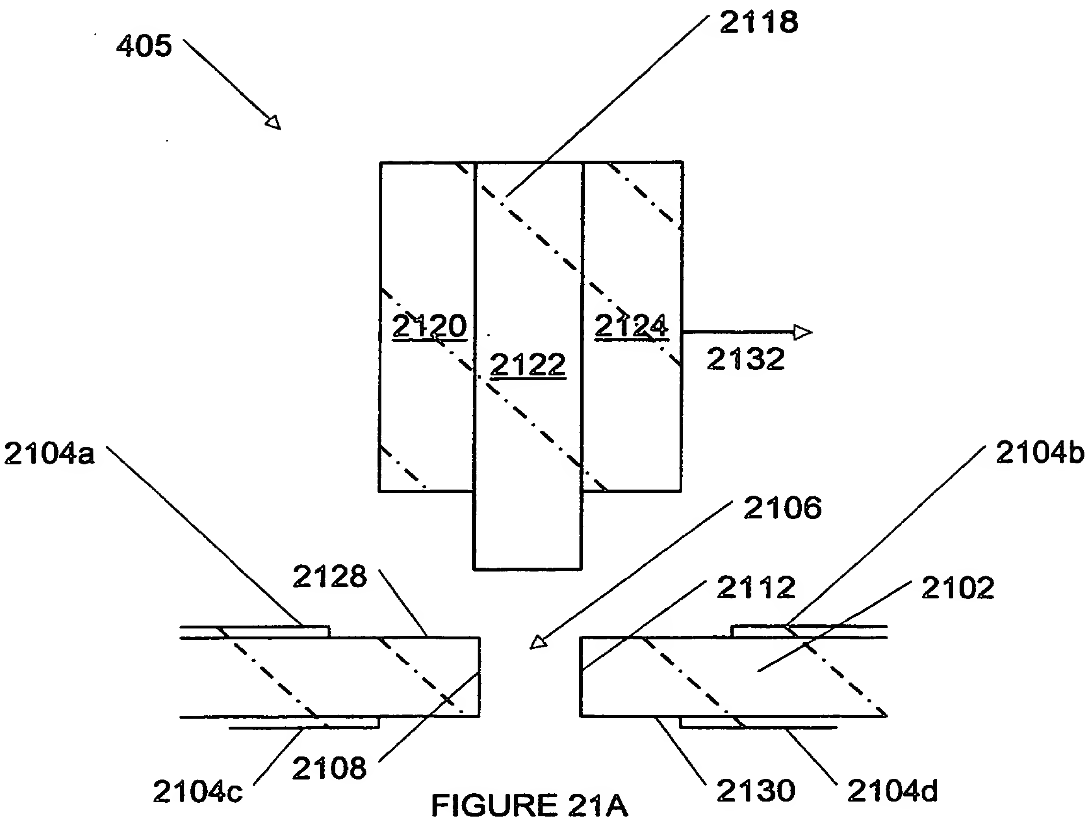

FIGURE 21A

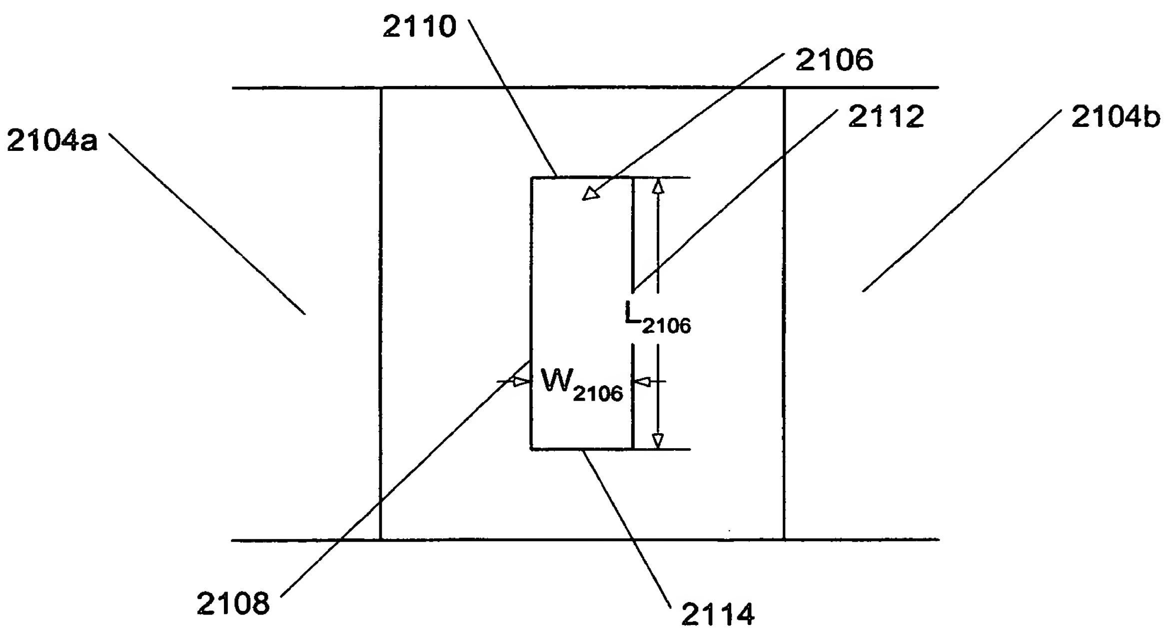

FIGURE 21B

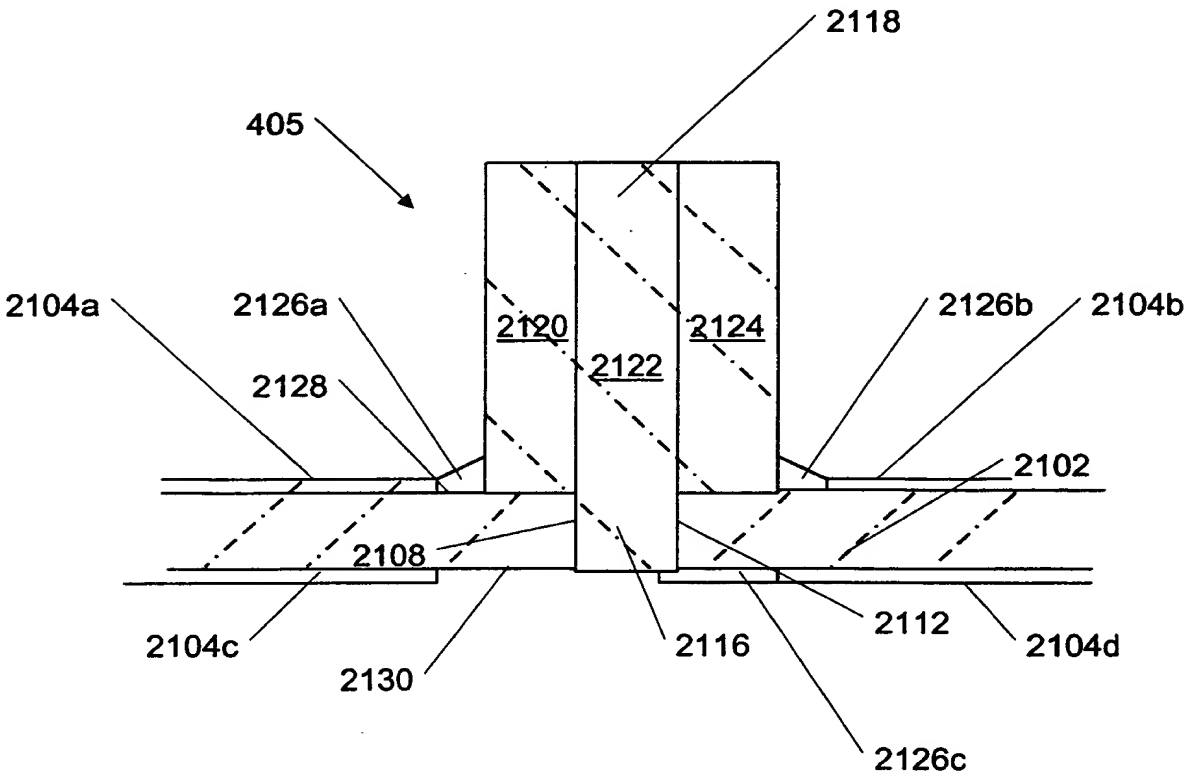
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FIGURE 21C

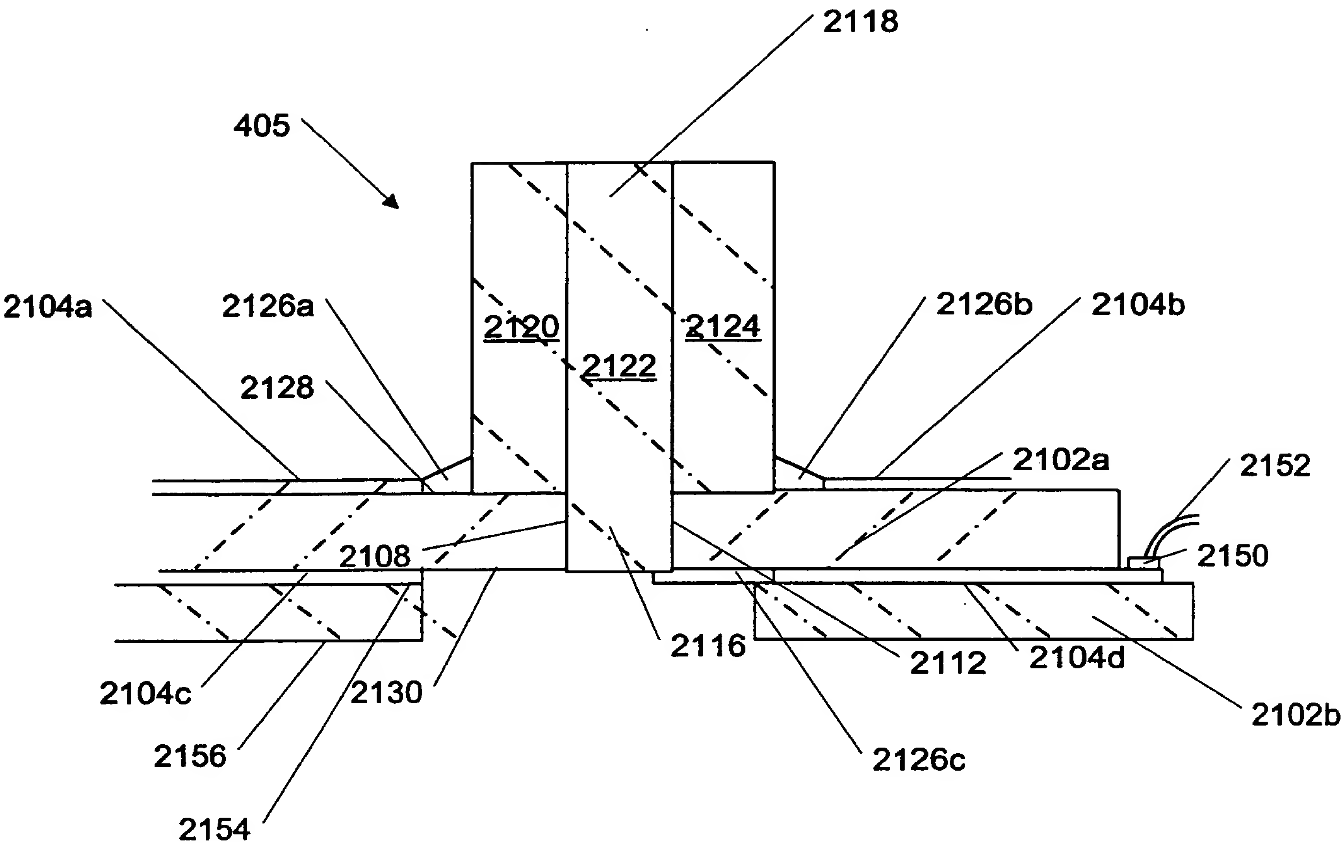
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FIGURE 21D

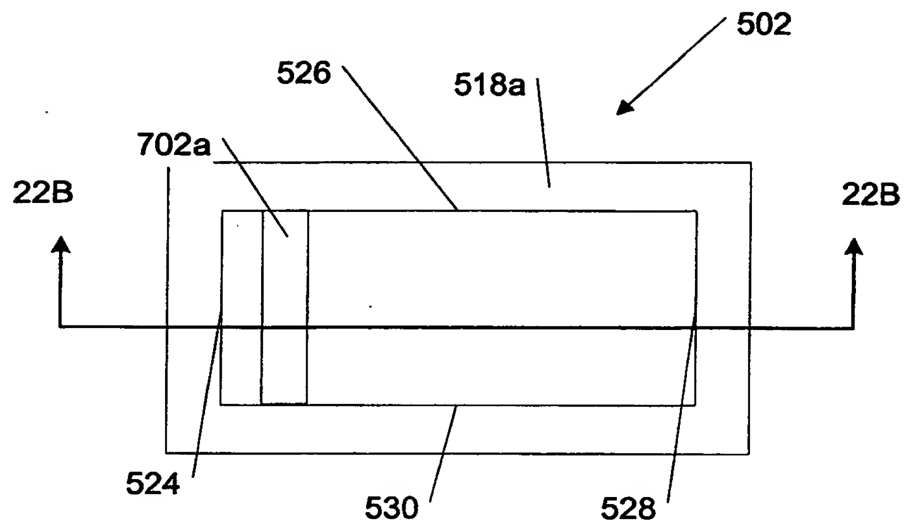

FIGURE 22A

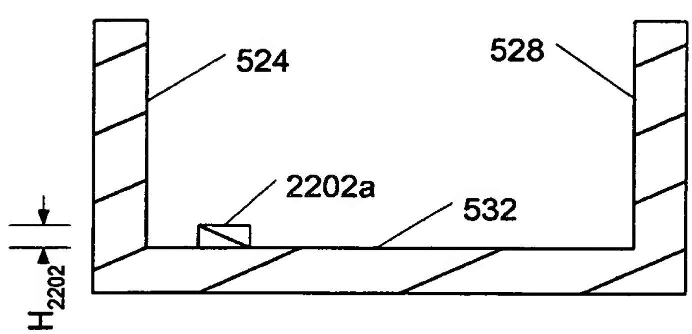

FIGURE 22B

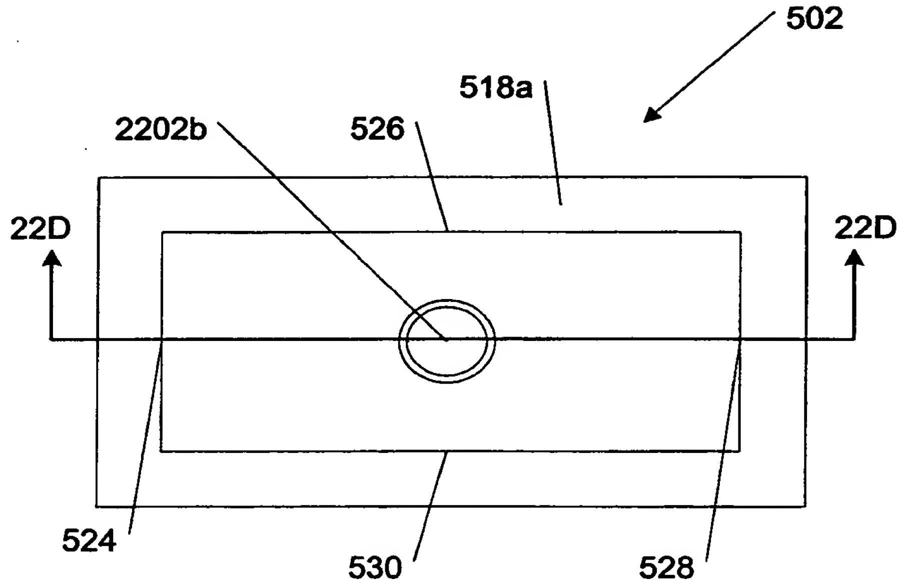

FIGURE 22C

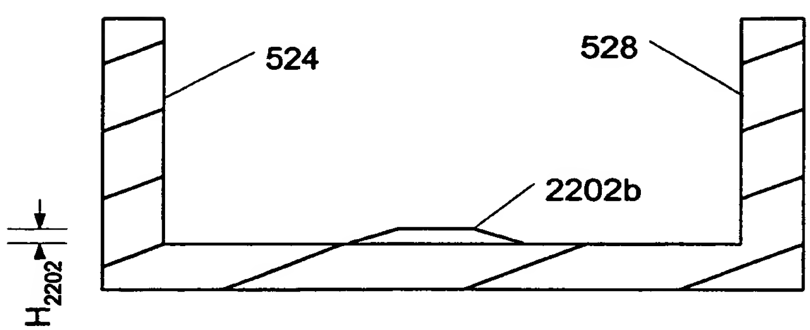

FIGURE 22D

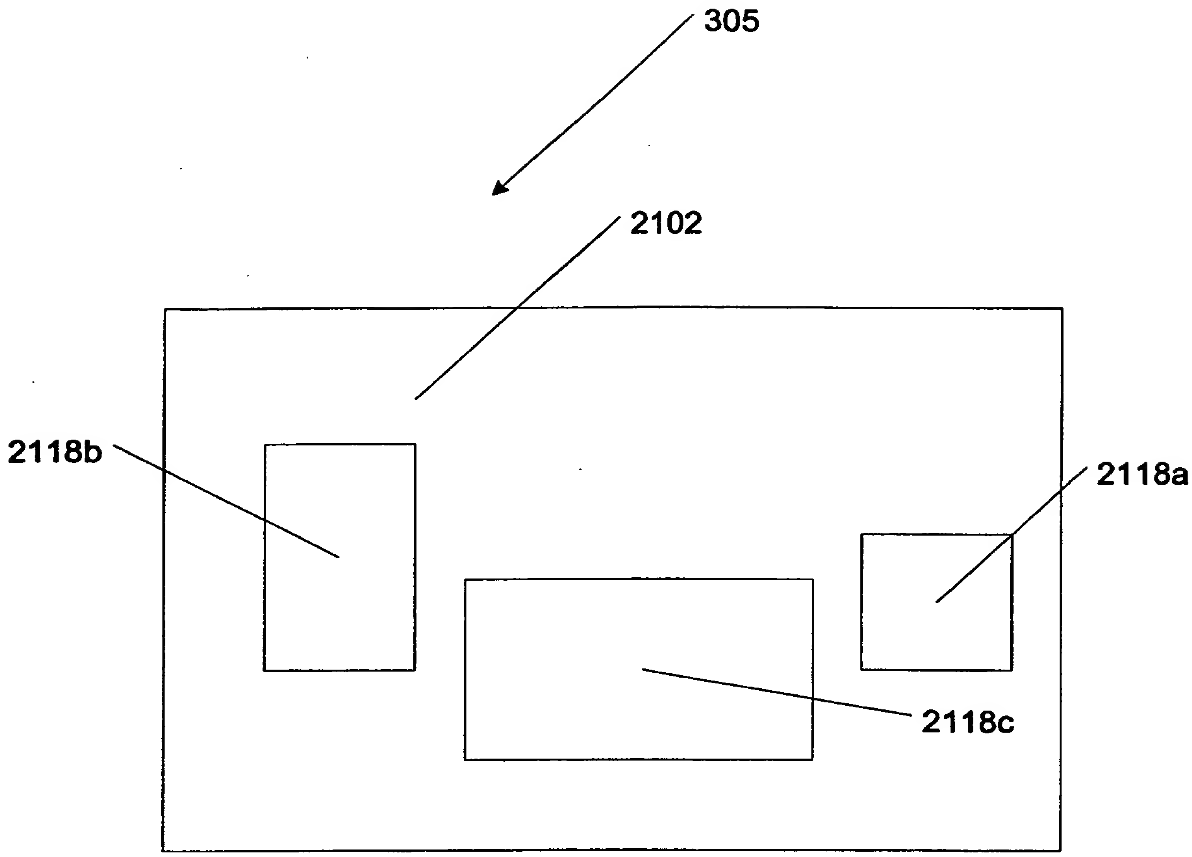

FIGURE 23A

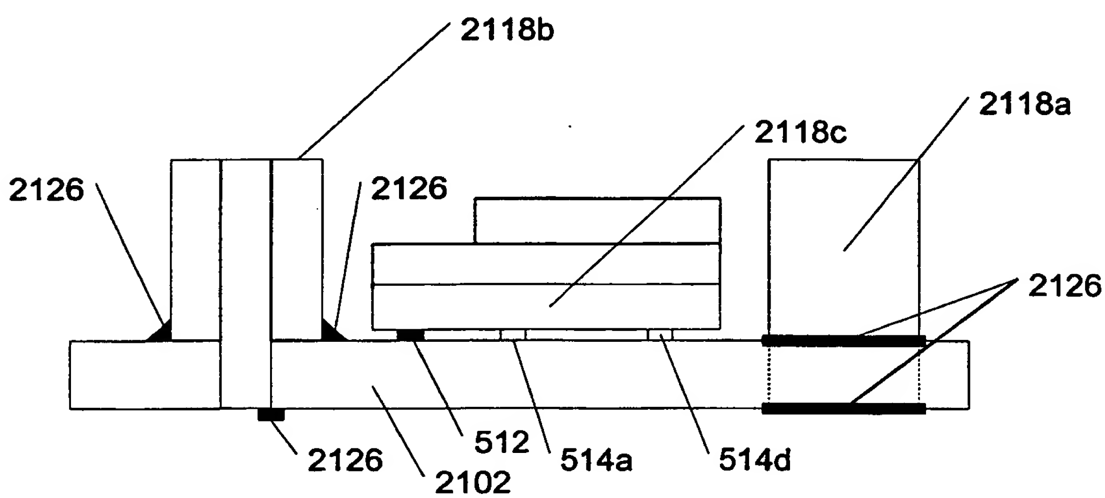

FIGURE 23B

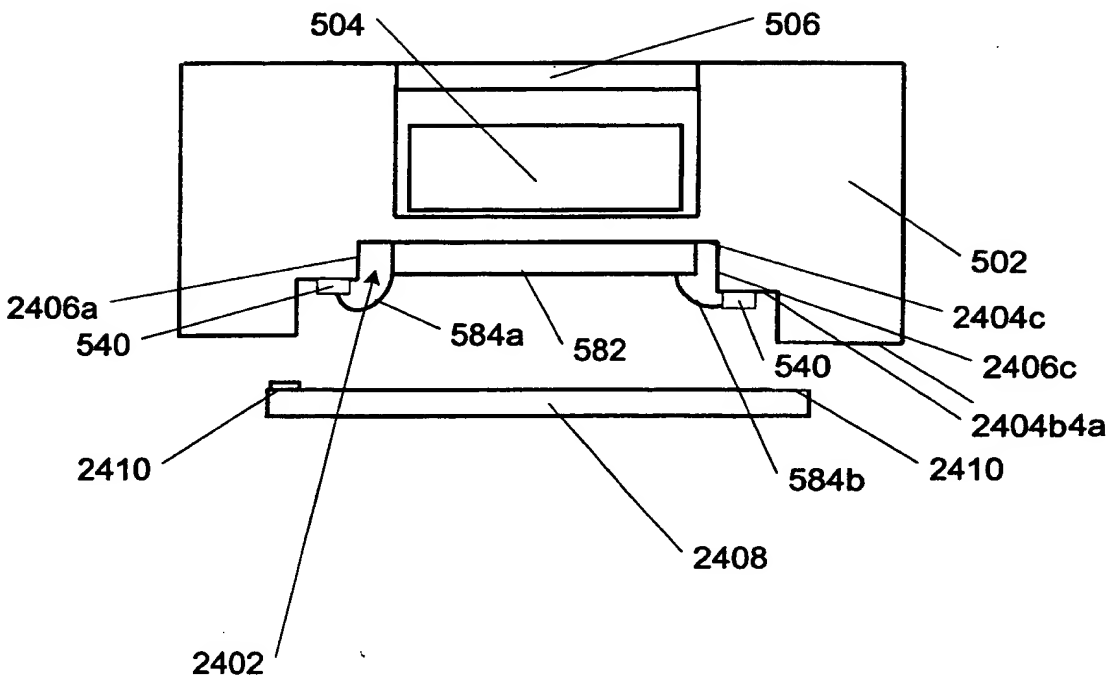
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FIGURE 24

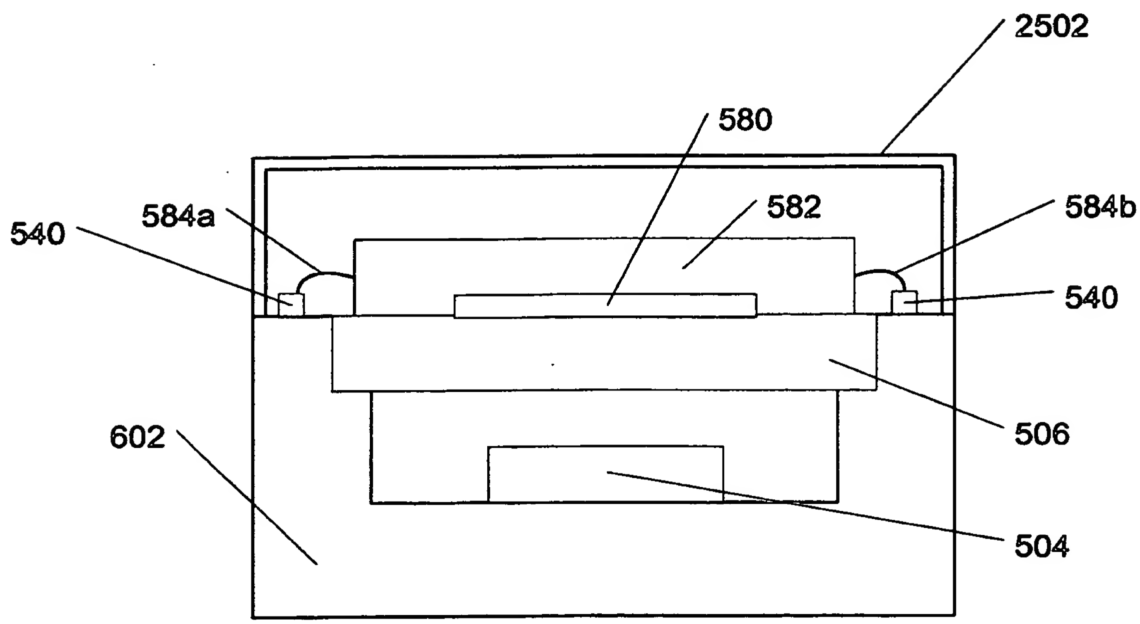

FIGURE 25A

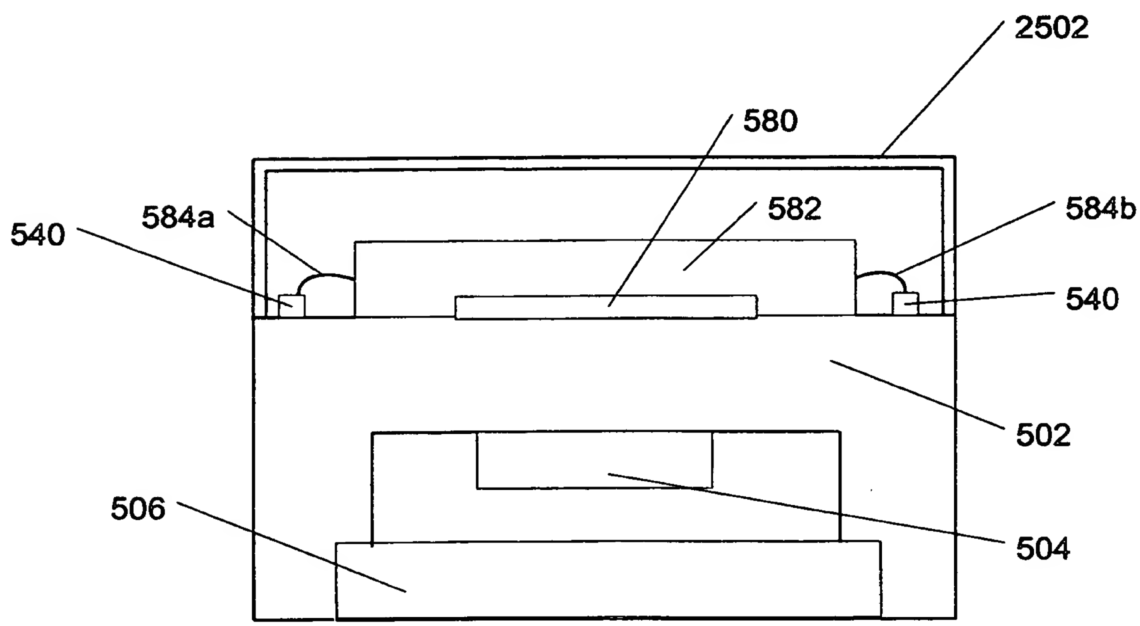

FIGURE 25B

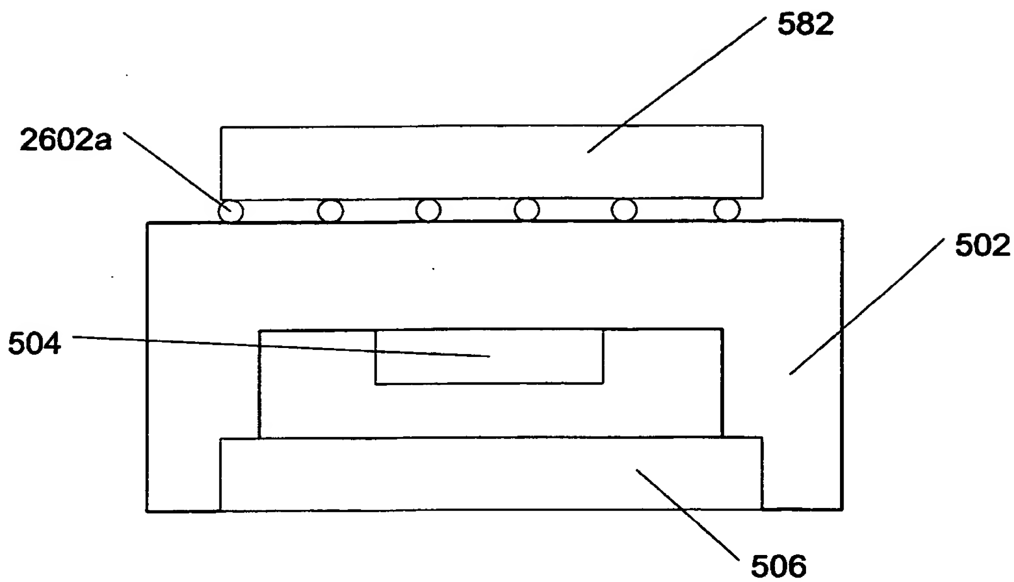

FIGURE 26A

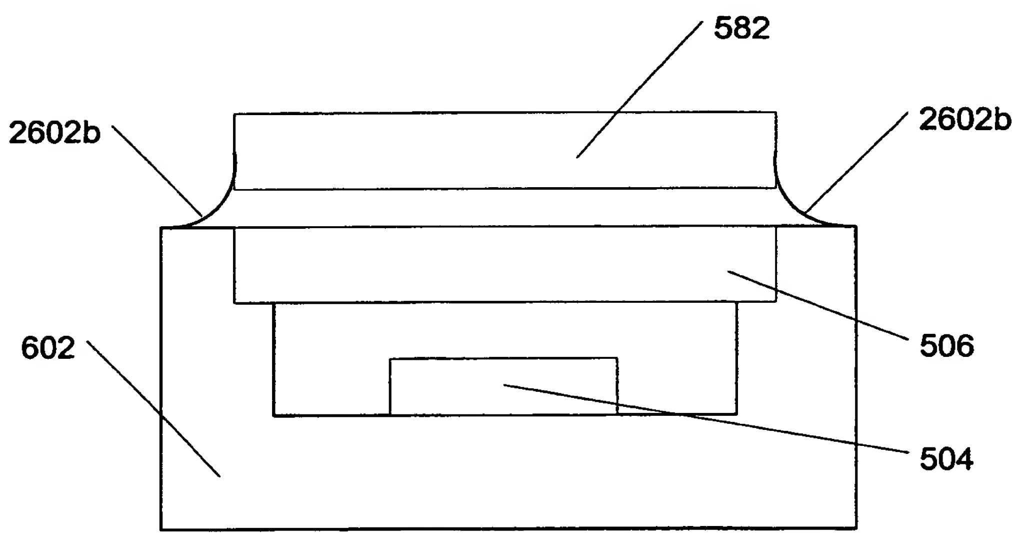

FIGURE 26B

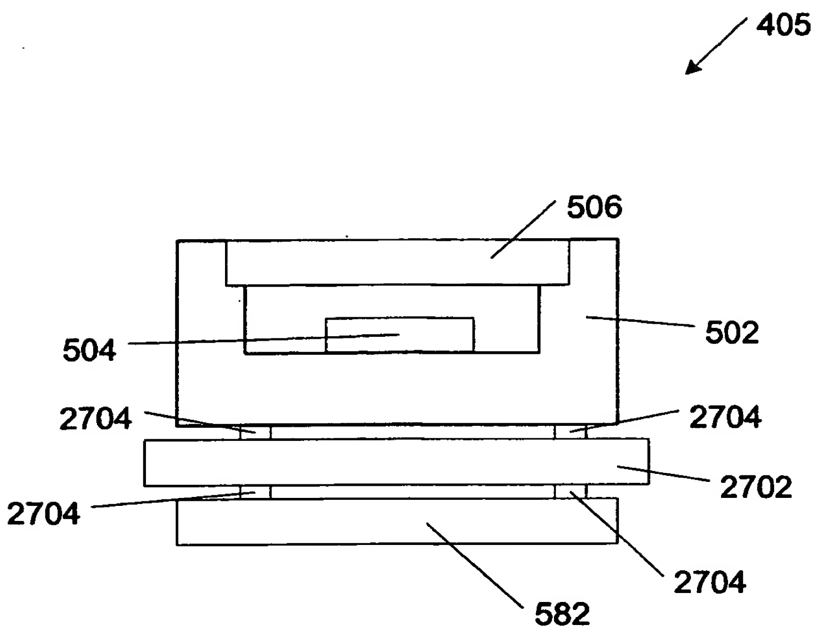

FIGURE 27A

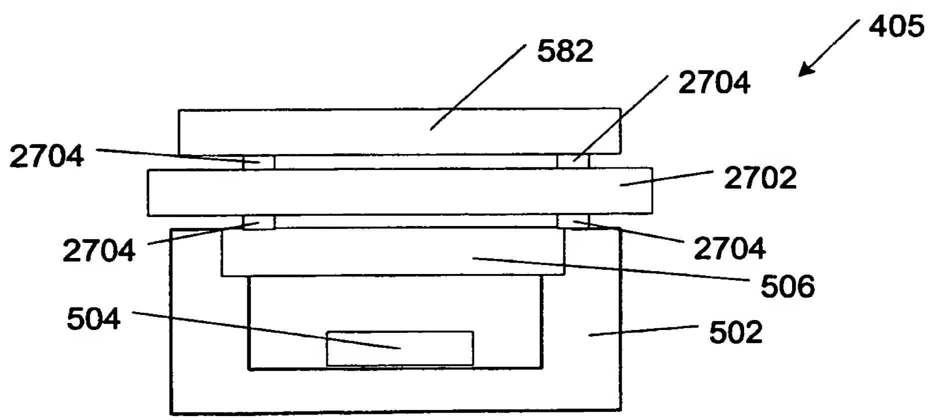

FIGURE 27B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/07310

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G01D 11/24, 21/00; B65D 85/38
US CL : 73/431; 29/595, 592.1, 825; 206/305

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 73/431; 29/595, 592.1, 825; 206/305

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y --- X	US 5,490,323 A (THACKER et al) 13 February 1996, (13/02/96) abstract, Figs. 13-16 and 22-23, col. 9, lines 10-22, col. 9, line 62-col. 10, line 10 and col. 11. lines 39-47	1, 4 --- 2, 5, 8
Y --- X	US 4,437,243 A (BROWN) 20 March 1984, (20/03/84) abstract and Fig. 1	1 --- 2-3, 5-6, 8
X, P	WO 99/16129 A (I/O OF AUSTIN, INC.) 01 April 1999, (01/04/99) abstract and Figs. 1 and 6	2, 5, 7-8
X --- Y	US 3,863,192 A (GREY) 28 January 1975, (28/01/75) abstact and Fig. 3	2, 5, 8 --- 4

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 MAY 2000	13 JUN 2000

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	TOM NOLAND
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4765

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/07310

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,784,260 A (FULLER, Jr. et al) 21 July 1998, (21/07/98) abstract and Figs. 5-8	4, 7
X --- Y	US 5,783,748 A (OTANI) 21 July 1998, (21/07/98) abstract and Figs. 1-2, 5-6, 8-17 and 21	2, 5, 8 --- 7
Y	US 5,294,829 A (HUNDT) 15 March 1994, (15/03/94) col. 1, lines 32-50, col. 3, lines 38-66 and col. 4, lines 48-56	4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/07310

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

WEST: files USPT, DWPI, JPAB, EPAB, TDBD
search terms: sensor, transducer, end, cap, ends!, caps!, seal, sealing, o!, ring, "o-ring", oring, axis!, axises!. axes!, sensitivity, sensing, sense, sensed, differ, differed, differing, different, package, encapsulate, encapsulated, encapsulating, encapsulation, controller, controllor, regulator, regulater, wire, bond, wirebond, "wire-bond", bonding, "wire-bonding", wirebonding, cure, cured, curing, adhesive, couple, coupling, coupled, substrate, slot, slotted, (73/431 or 29/595 or 29/592.1 or 29/825 or 206/305).ccls., (g01d011/24 or g01d021/00 or g01r003/00 or h01r043/02 or h01r043/00 or b65d085/38).ipc.

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, main invention, claims 1, 3 and 6, drawn to a sensor apparatus, a sensor assembly package, or a method of asssembling a multi-axis sensor assembly.

Group II, claims 2 and 5, drawn to a sensor pacckage or a method of assembling a sensor package including a package and a sensor.

Group III, claim 4, drawn to a method of coupling a controller onto a package.

Group IV, claims 7-8, drawn to a sensor module package or a method of assembling a sensor package comprising one or more substrates and one or more sensors.

The inventions listed as Groups I-IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I requires the special technical feature of a plurality of sensor packages which is not required in any other group.

Group II requires the special technical feature of coupling a sensor to a package which is not required in any other group.

Group III requires the special technical feature of the use of an adhesive which is not required in any other group.

Group IV requires the special technical feature of the use of substrates which is not required in any other group.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

To: TODD A. BYNUM
MADAN, MOSSMAN & SRIRAM, P.C.
2603 AUGUSTA, SUITE 700
HOUSTON, TX 77057

Date of Mailing (*day/month/year*) 23 MAY 2001

Applicant's or agent's file reference 14737.739.02		**IMPORTANT NOTIFICATION**
International application No. PCT/US00/07310	International filing date (*day/month/year*) 17 MARCH 2000	Priority Date (*day/month/year*) 17 MARCH 1999
Applicant INPUT/OUTPUT, INC.		

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

   The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

   Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

   For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer TOM NOLAND Telephone No. (703) 305-4765

PATENT COOPERATION TREATY

PCT

REC'D 28 MAY 2001
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

14

Applicant's or agent's file reference 14737.739.02	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US00/07310	International filing date *(day/month/year)* 17 MARCH 2000	Priority date *(day/month/year)* 17 MARCH 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): G01D 11/24, 21/00; B65D 85/38 and US Cl.: 73/431; 29/595, 592.1, 825; 206/305		
Applicant INPUT/OUTPUT, INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 65 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☒ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand 13 OCTOBER 2000	Date of completion of this report 11 MAY 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer TOM NOLAND Telephone No. (703) 305-4765

INTERNATIONAL PRE[redacted]ARY EXAMINATION REPORT

International application No.
[redacted]S00/07310

I. Basis of the report

1. With regard to the **elements** of the international application:*

[ ] the international application as originally filed

[X] the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

[X] the claims:
pages (See Attached), as originally filed
pages ______, as amended (together with any statement) under Article 19
pages ______, filed with the demand
pages ______, filed with the letter of ______

[X] the drawings:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

[X] the sequence listing part of the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______ which is:

[ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

[ ] the language of publication of the international application (under Rule 48.3(b)).

[ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

[ ] contained in the international application in printed form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. [X] The amendments have resulted in the cancellation of:

[X] the description, pages NONE

[X] the claims, Nos. NONE

[X] the drawings, sheets/~~fig~~ NONE

5. [ ] This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

- ☐ restricted the claims.
- ☐ paid additional fees.
- ☐ paid additional fees under protest.
- ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

- ☐ complied with.
- ☒ not complied with for the following reasons:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, main invention, claims 1, 3 and 6, drawn to a sensor apparatus, a sensor assembly package, or a method of assembling a multi-axis sensor assembly.
Group II, claims 2 and 5, drawn to a sensor package or a method of assembling a sensor package including a package and a sensor.
Group III, claim 4, drawn to a method of coupling a controller onto a package.
Group IV, claims 7-8, drawn to a sensor module or a method of assembling a sensor package comprising one or more substrates and one or more sensors.
The inventions listed as Groups I-IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:
Group I requires the special technical feature of a plurality of sensor packages which is not required in any other group.
Group II requires the special technical feature of coupling a sensor to a package which is not required in any other group.
Group III requires the special technical feature of the use of an adhesive which is not required in any other group.
Group IV requires the special technical feature of the use of substrates which is not required in any other group.

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

- ☒ all parts.
- ☐ the parts relating to claims Nos. _.

INTERNATIONAL PRELIM[redacted]RY EXAMINATION REPORT

Intern[redacted]nal application No.
P[redacted]00/07310

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1, 4	YES
	Claims	2-3, 5-8	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-8	NO
Industrial Applicability (IA)	Claims	1-8	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claim 1 lacks an inventive step under PCT Article 33(3) as being obvious over Brown in view of Thacker et al. Brown especially in its abstract and Fig. 1 shows an implantable sensor apparatus with what inherently could be considered a sensor module with a plurality of sensor packages with differently directioned axes of sensitivity. It does not show such positioning in a capped housing strucure as claimed but such would have been obvious for ease of sealing and stability in view of the teaching of such in the capped implantable sensor of Thacker et al, especially in the abstract, Figs. 13-16 and 22-23, col.9, lines 10-22, col. 9, line 62 - col. 10, line 10 and col. 11, lines 39-47 thereof.

Claims 2-3, 5-6 and 8 lack novelty under PCT Article 33(2) as being anticipated by Brown. Note at least a portion of the sensor is coupled to what could be considered a substrate.

Claim 4 lacks an inventive step under PCT Article 33(3) as being obvious over Hundt in view of Grey. Hundt especially in col. 1, lines 32-50, col. 3, lines 38-66 and col. 4, lines 48-56 shows a method of coupling a device that could be considered to inherently include a controller on a package as set forth but does not disclose the use of an adhesive as claimed. However such is a well known circuit manufacturing expedient as evidenced Grey, especially in his abstract and Fig. 3, and thus would have been an obvious method of incorporation for ease of manufacture.

Claim 7 lacks novelty under PCT Article 33(2) as being anticipated by Otani. Note especially its abstract and Figs. 1-2, 5-6, 8-17 and 21.

-------------------- NEW CITATIONS --------------------
NONE

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

I. BASIS OF REPORT:

This report has been drawn on the basis of the description.
page(s) NONE, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 1-29, filed with the letter of 15 March 2001

This report has been drawn on the basis of the claims,
page(s) NONE, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 30-31, filed with the letter of 15 March 2001

This report has been drawn on the basis of the drawings,
page(s) NONE, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 1-34, filed with the letter of 15 March 2001

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

INTEGRATED SENSOR PACKAGING AND MULTI-AXIS SENSOR ASSEMBLY PACKAGING

Background of the Invention

The present disclosure relates generally to the packaging of a sensor assembly, and in particular to packaging a multi-axis sensor assembly.

In packaging a multi-axis sensor assembly, high vector fidelity and low cross-axis sensitivity between the three major axes (x-axis, y-axis, and z-axis) is generally required. Orthogonally mounting three single-axis sensors typically results in low vector fidelity and high cross-axis sensitivity. There are also numerous manufacturing steps.

The present invention is directed at creating a multi-axis sensor package that has high vector fidelity, low cross-axis sensitivity, and a minimum number of manufacturing steps.

Summary of the Invention

According to one aspect of the invention, an apparatus is provided that includes a housing, a plurality of end caps, a sensor module, a plurality of sealing members, and a plurality of coupling members.

According to another aspect of the invention, an apparatus is provided that includes a housing, a sensor, a lid assembly, and a controller assembly.

According to another aspect of the invention, an apparatus is provided that includes a plurality of sensor packages, each sensor package having an axis of sensitivity positioned in a different spatial direction.

According to another aspect of the invention, a method of coupling a controller to a housing is provided that includes dispensing an adhesive on the housing, placing the controller on the housing, curing the adhesive, wire-bonding the controller to the housing, encapsulating the controller and wire-bonds, and curing the encapsulant.

According to another aspect of the invention, a method of assembling a sensor package including of a housing, a sensor, a controller, and a lid assembly is provided that includes coupling the sensor to the housing, coupling the lid assembly to the housing, and coupling the controller to the housing.

According to another aspect of the invention, a method of assembling a multi-axis sensor assembly is provided that includes a plurality of sensor packages, each sensor package having an axis of sensitivity positioned in a different spatial direction.

According to another aspect of the invention, a sensor package is provided that includes a substrate including a slot and a sensor positioned within the slot.

According to another aspect of the invention, a method of assembling a sensor package is provided that includes a substrate and a sensor, including coupling the sensor to the substrate.

Brief Description of the Drawings

Fig. 1 is a schematic view illustrating an embodiment of a system for sensor measurement.

Fig. 2 is a cross-sectional view of an embodiment of the sensor apparatus of Fig. 1.

Fig. 3 is a schematic view of an embodiment of the sensor module of Fig. 2.

Fig. 4A is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 4B is a bottom view of an embodiment of the housing of the sensor package of Fig. 4A.

Fig. 5A is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 5B is a bottom view of an embodiment of the housing of the sensor package of Fig. 5A.

Fig. 6A is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 6B is a bottom view of an embodiment of the lid assembly of the sensor package of Fig. 6A.

Fig. 7 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 8 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 9 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 10 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 11 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 12 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 13 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 14 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 15 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 16A is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 16B is a schematic view of an embodiment of the spring assembly of the sensor package of Fig. 16A.

Fig. 16C is a schematic view of an embodiment of the shorting clip of the sensor package of Fig. 16A.

Fig. 17 is a cross-sectional view of an embodiment of the sensor package of Fig. 3.

Fig. 18 is a schematic view of an alternate embodiment of the sensor module of Fig. 2.

Fig. 19 is a schematic view of an alternate embodiment of the sensor module of Fig. 2.

Fig. 20A is a cross-sectional view of an alternate embodiment of the sensor package of Fig. 3 before coupling.

Fig. 20B is a top view of an embodiment of the sensor package of Fig. 20A.

Fig. 20C is a cross-sectional view of an embodiment of the sensor package of Fig. 20A after coupling.

Fig. 20D is a cross-sectional view of an alternate embodiment of the sensor package of Fig. 20A.

Fig. 21A is a top view of an alternate embodiment of the apparatus of Fig. 4A.

Fig. 21B is a cross-sectional view of the apparatus of Fig. 21A.

Fig. 21C is a top view of an alternate embodiment of the apparatus of Fig. 4A.

Fig. 21D is a cross-sectional view of the apparatus of Fig. 21C.

Fig. 22A is a top view of an alternate embodiment of the sensor module of Fig. 2.

Fig. 22B is a cross-sectional view of an alternate embodiment of the sensor module of Fig. 22A.

Fig. 23 is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Fig. 24A is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Fig. 24B is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Fig. 25A is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Fig. 25B is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Fig. 26A is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Fig. 26B is a schematic view of an alternate embodiment of the sensor package of Fig. 3.

Detailed Description of the Illustrative Embodiments

Referring initially to Fig. 1, an embodiment of a system 100 for recording seismic information preferably includes a controller 102 and a sensor apparatus 104.

The controller 102 monitors and controls the system 100. The controller 102 preferably receives data from the sensor apparatus 104. The controller 102 preferably monitors the sensor apparatus 104. The controller 102 is coupled to the sensor apparatus 104 by electrical connections. The controller 102 may be any number of conventional commercially available controllers, for example, of the type integrated circuit chips. In a preferred embodiment, the controller 102 is an application specific integrated chip for readout and control of the sensor.

In one embodiment, the sensor apparatus 104 ranges from about 0.75 inches to 1 inch in diameter for reduced cross-sectional area. In one embodiment, the sensor apparatus 104 is waterproof and pressure-proof for environmental protection.

Referring to Fig. 2, an embodiment of the sensor apparatus 104 includes a housing 205 coupled to a first end cap 210, a second end cap 215 and a sensor module 305. The housing 205 is coupled to the end caps 210 and 215 by coupling members such as mechanical fasteners 310, 315, 320 and 325. The mechanical fasteners are preferably capable of being torqued to a predetermined position in for mechanical coupling.

Sealing members 330a-d seal the interface between the housing 205 and the first end cap 210, and sealing members 335a-d seal the interface between the housing 205 and the second end cap 215. The sealing members 330a-d and 335a-d may be elastomer rings capable of being compressed to a predetermined position for sealing. The number of sealing members used is based on the sealing requirements of the interface between the housing 205 and the respective end cap 210 and 215.

The housing 205 preferably includes a cavity 340 and a planar surface 345. The housing 205 may be metal tubing. In one embodiment, the housing 205 is a metal tube fabricated from high strength materials in order to provide a robust pressure vessel.

The sensor module 305 is supported by the planar surface 345 within the cavity 340 of the housing 205 and is coupled to the first end cap 210 by a PC-board connection 355.

AMENDED SHEET

In several alternate embodiments, the sensor module 305 may be used in a variety of sensor apparatuses 104, for example, geophone packages, inclinometers, inertial guidance systems, and vibration monitor.

Referring to Fig. 3, the sensor module 305 preferably includes sensor packages 405a-c and a substrate 410. Each sensor package 405a-c includes a corresponding axis of sensitivity 415, 420 and 425. Each axis of sensitivity 415, 420 and 425 is approximately parallel to the x-axis, y-axis and z-axis, respectively.

The sensor packages 405a-c may be coupled to the substrate 410 using one of the following methods: solder-paste surface mount, solder-ball, or leads. The sensor packages 405a-c are preferably coupled to the substrate 410 by solder paste surface mount to provide low profile components. The substrate 410 is preferably a ceramic PC-board having high temperature capability. The substrate 410 may alternatively be an organic PC-board.

Referring to Figs. 4A and 4B, an embodiment of the sensor package 405 preferably includes a housing 502, a sensor 504, a lid assembly 506, and a controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 502. The controller assembly 508 is preferably coupled to the bottom of the housing 502. The sensor 504 is preferably coupled within the housing 502.

The housing 502 is preferably coupled to the sensor 504, the lid assembly 506, the controller assembly 508, one or more electrical connections 510, one or more resilient couplings 512, and one or more sliding supports 514. The housing 502 preferably includes a cavity 516, one or more planar surfaces 518, one or more exterior surfaces 520, and a bottom exterior surface 522. The cavity 516 preferably includes a first wall 524, a second wall (not shown), a third wall 528 and a fourth wall (not shown). The first wall 524 and the third wall 528 are preferably approximately parallel to each other and the second wall and the fourth wall are preferably approximately parallel to each other. The second wall and the fourth wall are also preferably perpendicular to the first wall 524 and the third wall 528. The cavity 516 preferably includes a bottom surface 532. The bottom surface 532 may be ceramic. In one

AMENDED SHEET

embodiment, the bottom surface 532 is gold plated to enhance soldering. The housing 502 may be a conventional ceramic, plastic, or metal housing. A ceramic housing is preferable for vacuum sealing capability.

The housing 502 includes a first planar surface 518a, a second planar surface 518b, a third planar surface 518c, and a fourth planar surface 518d. The first planar surface 518a preferably includes one or more planar bond pads 534. The planar bond pads 534 are approximately rectangularly shaped. The planar bond pads 534 may be used for solder paste, solder balls or leads attachment. In one embodiment, the planar bond pads 534 are used to solder the sensor packages 405 to the substrate 410. The number of planar bond pads 534 depends on having sufficient planar bond pads 534 to connect the controller assembly 508 to the housing 502. The second planar surface 518b may be plated with a metal such as gold to enhance soldering. The third and fourth planar surfaces 518c-d may be plated with gold for wire bonding.

The housing 502 includes a plurality of first exterior surfaces 520a and a plurality of second exterior surfaces 520b. In one embodiment, there are four first exterior surfaces 520a and four second exterior surfaces 520b forming an approximate octagon. The second exterior surfaces 520b preferably couple the first exterior surfaces 520a to each other. The first exterior surfaces 520a preferably include one or more exterior bond pads 536. The exterior bond pads 536 are preferably approximately rectangularly shaped. The exterior bond pads 536 may be used for solder paste, solder ball or leads attachment. In one embodiment, the exterior bond pads 536 are used to solder the sensor package 405 to the substrate 410. In an alternate embodiment, the exterior bond pads 536 are on a single first exterior surface 520a

The bottom exterior surface 522 of the housing 502 preferably includes a contact pad 538, one or more bond pads 540, and one or more connecting pads 542. The contact pad 538 may be gold-plated to provide a reliable electrical connection. The planar bond pads 534 on the first planar surface 518a are preferably electrically coupled to the bond pads 540 on the bottom exterior surface 522 by electrical paths molded into the housing 502. The resilient couplings 512, the third planar surface 518c and the fourth planar surface 518d

AMENDED SHEET

are preferably coupled to the bond pads 540 on the bottom exterior surface 522 by electrical paths molded into the housing 502. The bond pads 540 may be gold-plated for wire bonding. The number of bond pads 540 depends on having sufficient bond pads 540 to connect the controller assembly 508 to the housing 502. The connecting pads 542 preferably connect the contact pad 538 to the bond pads 540. The connecting pads 542 are preferably gold-plated to provide a conductive pathway between the contact pad 538 and the bond pads 540. In one embodiment, there is a first connecting pad 542a and a second connecting pad 542b. The exterior bond pads 536 may be electrically connected to the bond pads 540 by electrical paths molded into the housing 502.

The sensor 504 is preferably resiliently attached to the housing 502 by the resilient couplings 512, slidingly supported by the sliding supports 514, and electrically coupled to the housing 502 by the electrical connections 510. The sensor 504 may have an approximately rectangular cross-sectional shape. The sensor 504 preferably has a passive region 566 at one end and an active region 588 at an opposite end. In one embodiment, the sensor 504 includes a first member 544, a second member 546, and a third member 548. The first member 544 is preferably on top of the second member 546 and the second member 546 is preferably on top of the third member 548. In one embodiment, the first member 544, the second member 546, and the third member 548 are a micro machined sensor substantially as disclosed in copending PCT Patent Application Serial No. US00/40039, filed on March 16, 2000, the contents of which are incorporated herein by reference.

The first member 544 includes one or more parallel planar surfaces such as a top parallel planar surface 550. The second member 546 includes one or more parallel planar surfaces such as a middle parallel planar surface 552. The third member 548 includes one or more parallel planar surfaces such as a bottom parallel planar surface 554.

The bottom parallel planar surface 554 of the sensor 504 includes a first side, a second side, a third side, and a fourth side 562 not separately numbered. The first through fourth sides provide the bottom parallel planar surface 554 a substantially rectangular or square cross-sectional shape.

In one embodiment, the bottom parallel planar surface 554 of the sensor 504 includes one or more bond pads 564 located in the passive region 566 of the bottom parallel planar surface 554 of the sensor 504. The bond pads 564 may be located a perpendicular distance ranging from about 5 to 25 mils from the first side of the bottom parallel planar surface 554 and may be located a perpendicular distance ranging, for example, from about 5 to 25 mils from the second side of the bottom parallel planar surface 554. In one embodiment, the bond pads 564 are located a perpendicular distance ranging from about 7 to 12 mils from the first and second sides of the bottom parallel planar surface 554 to reduce effects of thermal stress.

The bond pads 564 may be used for solder, conductive epoxy, non-conductive epoxy or glass frit bonding. In one embodiment, the bond pads 564 are used for solder bonding to provide ease of manufacture. In one embodiment, the bond pads 564 contact area selected to provide shock tolerance for the sensor 504. The bond pads 564 should have minimal discontinuities to facilitate distribution of thermal stresses in the sensor 504. In several alternate embodiments, there are a plurality of bond pads 564 to relieve thermal stresses in the sensor 504. There may be a single bond pad 564a having an approximately rectangular cross-sectional shape. The length and width of the bond pad 564a may range from about 200 to 240 mils and 15 to 25 mils, respectively. In one embodiment, the length and width of the bond pad 564a ranges from about 200 to 220 mils and 18 to 22 mils, respectively, to reduce effects of thermal stress. The height of the bond pad 564a may range from about 0.1 to 1 micron, and preferably ranges from about 0.24 to 0.72 microns to reduce effects of thermal stresses.

The resilient couplings 512 resiliently attach the bond pads 564 to the housing 502. The resilient couplings 512 may electrically attach the sensor 504 to the housing 502. The resilient couplings 512 may be coupled to the bottom surface 532 of the cavity 516 of the housing 502. In one embodiment, the resilient couplings 512 are solder preforms. The resilient couplings 512 should have minimal discontinuities to facilitate distribution of thermal stresses in the sensor 504. In several alternate embodiments, there are a plurality of resilient

couplings 512 to re[illegible] thermal stresses in the sensor [illegible] The resilient couplings 512 may have an approximate cross-sectional rectangular shape, and be any number of conventional commercially available solder preforms of the type eutectic or non-eutectic. Eutectic type preforms provide good yield strength with a reasonable melt temperature. In one embodiment, there is a single resilient coupling 512a.

The length and width of the resilient coupling 512a may range from about 200 to 250 mils and 20 to 35 mils, respectively. In one embodiment, the length and width of the resilient coupling 512a range from about 225 to 235 mils and 25 to 30 mils, respectively to reduce effects of thermal stresses. The height of the resilient coupling 512a may range from about 2 to 4 mils, and preferably ranges from about 2.5 to 3 mils.

The resilient couplings 512 may be located a perpendicular distance ranging from about 5 to 25 mils from the first and second walls 524 and 526 of the cavity 516 of the housing 502. In one embodiment, the resilient couplings 512 are located a perpendicular distance ranging from about 7 to 12 mils from the first and second walls 524 and 526 to relieve thermal stresses.

In another embodiment, the resilient couplings 512 further include one or more bumpers (not separately shown) for slidingly supporting the sensor 504. The bumpers are proximate to the bond pads 564. The width of each bumper may range from about 2 to 6 mils to reduce stresses. In one embodiment, the resilient couplings 512 are coupled to the bond pads 564 using conventional solder equipment and processes. The resilient couplings 512 may be coupled to the bottom surface 532 of the cavity 516 of the housing 502 using conventional solder equipment and processes.

The sliding supports 514 slidingly support the sensor 504 and are coupled to the bottom surface 532 of the cavity 516 of the housing 502. The sliding supports 514 may be tungsten or ceramic. In one embodiment, the sliding supports 514 have an approximately square cross sectional shape. The cross sectional area of the sliding supports 514 may range from about 400 to 1600 square mils, individually to reduce the effects of thermal stresses. The height of the sliding supports 514 may range from about 0.5 to 3 mils. The

number of sliding supports 514 depends on having sufficient sliding supports 514 to slidingly support the sensor 504.

In another embodiment, there is a first sliding support 514a, a second sliding support (not shown), a third sliding support (not shown), and a fourth sliding support 514d. The first sliding support 514a is located adjacent to one side of the resilient couplings 512. The second sliding support is located adjacent to the first sliding support 514a. The third sliding support is located adjacent to one side of the resilient couplings 512 and approximately perpendicular to the first sliding support 514a. The fourth sliding support 514d is located adjacent to the third sliding support.

The first sliding support 514a may be located a perpendicular distance ranging from about 45 to 75 mils and about 85 to 115 mils from the first wall 524 and second wall of the cavity 516, respectively. In one embodiment, the first sliding support 514a is located a perpendicular distance ranging from about 52 to 62 mils and about 90 to 105 mils from the first wall 524 and second wall of the cavity 516, respectively to reduce thermal stresses.

The second sliding support may be located a perpendicular distance ranging from about 45 to 75 mils and about 15 to 30 mils from the first wall 524 and second wall of the cavity 516, respectively. In one embodiment, the second sliding support is located a perpendicular distance ranging from about 52 to 62 mils and about 20 to 25 mils from the first wall 524 and second wall of the cavity 516, respectively to reduce thermal stresses.

The third sliding support may be may be located a perpendicular distance ranging from about 85 to 115 mils and about 15 to 30 mils from the first wall 524 and second wall of the cavity 516, respectively. In one embodiment, the third sliding support is located a perpendicular distance ranging from about 90 to 105 mils and about 20 to 25 mils from the first wall 524 and second wall of the cavity 516, respectively, to reduce thermal stresses.

The fourth sliding support 514d may be located a perpendicular distance ranging, for example, from about 85 to 115 mils from the first wall 524 and second wall of the cavity 516 of the housing 502. In one embodiment, the fourth sliding support 514d is located a perpendicular distance ranging from

about 90 to 105 m[illegible]om the first wall 524 and secon[illegible]l of the cavity 516 to reduce thermal stresses. The sliding supports 514 are coupled to the bottom surface 532 of the cavity 516 of the housing 502 using conventional techniques for integrating the sliding supports 514 into the housing 502.

The electrical connections 510 electrically couple the sensor 504 to the housing 502. In one embodiment, the electrical connections 510 are wire bonds selected from conventional commercially available wire bonds of the type aluminum or gold. In one embodiment, there is a first electrical connection 510a and a second electrical connection 510b. The first electrical connection 510a electrically couples the third planar surface 518c of the housing 502 to the top parallel planar surface 550 of the sensor 504. The second electrical connection 510b electrically couples the fourth planar surface 518d of the housing 502 to the middle parallel planar surface 552 of the sensor 504. In one embodiment, the electrical connections 510 are coupled to the housing 502 using conventional wire bonding equipment and processes.

The lid assembly 506 is coupled to the housing 502. The lid assembly 506 includes a lid 572 and a getter 574. The lid 572 may be Kovar™ or ceramic. The lid 572 is preferably alloy 42 to facilitate vacuum sealing. The lid 572 may be plated with an assortment of metals such as an industry standard composite layer of gold/nickel/gold/nickel for soldering. In one embodiment, the length and width of the lid 572 is at least 0.010 inches less than the length and width of the second planar surface 518b for alignment tolerance. The height of the lid 572 may range from about 0.01 inches to 0.02 for planarity with the housing 502.

The getter 574 may be any commercially available getter having length and width about 0.125 inches less than the length and width of the lid 572 for good vacuum ambient and alignment tolerance. The height of the getter 574 may range from about 0.005 inches to 0.020 inches for good vacuum ambient and alignment tolerance.

The lid 572 includes a bottom surface 576, and the getter 574 is coupled to the bottom surface 576 using conventional welding equipment and processes. The bottom surface 576 of the lid 572 is coupled to the housing 502 via a solder

preform 578 simil[...] material to the coupling 512 de[...]ed above. The solder preform 578 is coupled to the second planar surface 518b of the housing 502 using conventional solder equipment and processes. The solder preform 578 may be an approximately rectangular ring that conforms to the shape of the second planar surface 518b. The outer length and exterior width of the solder preform 578 is at least 0.010 inches less than the outer length and exterior width of the second planar surface 518b for good alignment tolerance. The height of the solder preform 578 ranges from about 0.0025 inches to 0.0035 for a good vacuum seal. The interior length and interior width of the solder preform 578 is at least as long as the interior length and interior width of the second planar surface 518b for alignment tolerance and a good solder seal. The lid 572 is coupled to the solder preform 578 using conventional vacuum sealing equipment and processes. The housing 502, the sensor 504, and the lid 506 are vacuum-sealed to remove excess gas from the cavity 516.

The controller assembly 508 may include an adhesive 580, a controller 582, one or more wire bonds 584, and an encapsulant 586. The controller assembly 508 is coupled to the bottom exterior surface 522 of the housing 502. The adhesive 580 is coupled to the contact pad 538. The adhesive 580 may be solder, epoxies or silicone-based. In one embodiment, the adhesive 580 is silicone-based for stress relief.

The controller 582 is coupled to the adhesive 580. The controller 582 may be an integrated circuit chip such as an application specific integrated chip (ASIC) for closed-loop control of the sensor 504. The adhesive 580 is cured using conventional curing methods for the adhesive 580 used.

The wire bonds 584 are coupled to the controller 582 and the bond pads 540. The wire bonds 584 may be aluminum or gold. The wire bonds 584 couple the bond pads 540 to the controller 582. The wire bonds 584 are coupled to the bond pads 540 and controller 582 using conventional wire bonding equipment and processes.

The controller 582 and the wire bonds 584 may be encapsulated with the encapsulant 586 such as glob top polymer having a depth sufficient for a

hermetic seal. The encapsulant 586 is cured using conventional curing methods for the encapsulant 586 used.

In an alternate embodiment, the housing 502 further includes circuit components that may be integrated into one or more of the housing 502 surfaces. In one embodiment, the circuit components are integrated into the bottom exterior surface 522 to reduce the size of the sensor module 405. The circuit components may be any electrical circuit components such as filtering capacitors, resistors, or active components.

Alternatively, one or more of the lid assembly 506, the controller assembly 508, the sliding supports 514, the getter 574, and the exterior bond pads 536 are optional

In several alternative embodiments, the overall geometry and number of the bond pads 564 may be selected according to application preferences. For example, the bond pads may be two or three bond pads substantially equal in size, horizontally or vertically spaced proximate to each other, and have an approximately rectangular or oval cross-sectional shape. There may be a single bond pad having an approximately oval, tri-oval, oct-oval or wavy-sided cross-sectional shape. There may be two bond pads horizontally proximate to each other and have an approximately rectangular cross-sectional shape, where one bond pad is smaller in size than the other bond pad.

The resilient coupling 512 described above may alternatively be two resilient couplings substantially equal and are vertically proximate to each other. In several alternate embodiments, the sliding supports 514 include one or more sliding supports. The sliding supports may have an approximately rectangular, triangular or circular cross-sectional shape.

Referring to Figs. 5A and 5B, an alternate embodiment of the sensor package 405 is shown that is substantially similar to the embodiment shown in Fig. 4A except that in the embodiment of Fig. 5A the controller assembly 508 is coupled to the top of a housing 602.

The housing 602 is coupled to the sensor 504, the lid assembly 506, the controller assembly 508, the electrical connections 510, the resilient couplings 512, and the sliding supports 514. The housing 602 includes a cavity 604, one

or more planar surfaces 606, one or more exterior surfaces such as bottom exterior surface 610. The cavity 604 includes a first wall 612, a second wall (not shown), a third wall 616, and a fourth wall (not shown). All walls 612, 616, pads 622, 626, surfaces 606a-d, 610, 620, 628, cavity 604, and housing 602 are all substantially as described above with respect to the embodiments shown in Fig. 4A with differences being only in the number and dimensions of the elements.

The bottom exterior surface 610 of the housing 602 differs from the bottom surface of the housing 502 described above and shown in Fig. 4B. The bottom exterior surface 610 includes one or more bond pads 626. The bond pads 626 may be approximately circular in shape and are used for solder paste, solder balls or leads attachments. In one embodiment, the bond pads 626 are gold plated for soldering. The number of bond pads 626 depends on having sufficient bond pads 626 to connect the sensor module 405 to the substrate 410. The planar bond pads 622 are electrically coupled to the bond pads 626 by electrical paths molded into the housing 602.

In several alternate embodiments, the bond pads 564, resilient couplings 512 and sliding supports 514 may be selected from the configurations described above with respect to the embodiment shown in Fig. 4A.

Referring to Fig. 6A an alternate embodiment of the sensor package 405 is shown that includes the housing 502, the sensor 504, a lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 502. The controller assembly 508 is preferably coupled to the bottom of the housing 502. The sensor 504 is preferably coupled within the housing 502. This embodiment is substantially similar to the embodiment described above and shown in Fig. 4A, except for an added spring in the lid assembly 702.

The lid assembly 702 is preferably coupled to the housing 502. The lid assembly 702 preferably includes a lid 704, a getter 706 and a spring 708. The lid 704 further preferably includes a bottom surface 710 and a top surface 712.

The spring 708 may be fabricated from 0.003" stainless steel or beryllium copper strips. In one embodiment the spring 708 is stainless steel for its

mechanical streng[illegible]nd stable properties. The spring [illegible] may be H-shaped defining a center bar and four arms. The spring 708 is welded to the bottom surface 710 of the lid 704. The four arms of the spring 708 preferably curl downwardly away from the bottom surface 710 of the lid 704. The four arms couple the bottom surface 710 of the lid 704 to the top parallel planar surface 550 of the sensor 504. The spring 708 secures the sensor 504 to the resilient couplings 512. The spring 708 electrically couples the sensor 504 to the housing 502.

Referring to Fig. 7, an alternate embodiment of the sensor package 405 preferably includes the housing 602, the sensor 504, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is preferably coupled to the top of the housing 602. The controller assembly 508 is preferably coupled to the top of the housing 602. The sensor 504 is preferably coupled within the housing 602. This embodiment combines the features of the previously shown and described embodiments in that the lid assembly of Fig. 6A including spring 708 is added to the top-mounted controller assembly of Fig. 5A. As such, all component variations applicable to the previously-described embodiments are considered equally applicable and described by reference for alternative embodiments based on the structure of Fig. 7.

Referring to Fig. 8, an alternate embodiment of the sensor package 405 preferably includes the housing 502, a sensor 902, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 502. The controller assembly 508 is preferably coupled to the bottom of the housing 502. The sensor 902 is preferably coupled within the housing 502. This embodiment includes a passive/active/passive configuration of the sensor 902 created by the use of resilient couplings 904, and sliding supports 940.

The sensor 902, resilient couplings 904, sliding supports 940, first passive region 928, second passive region 930, active region 942 located between the first and second passive regions 928 and 930 are all substantially as described above with respect to Fig. 4A with the exception of dual passive regions 928 and 930.

First member 906, second member 908, and third member 910 of sensor 902 are likewise similar to members 544, 546, and 548 described above and shown in Fig. 4A.

Surface 912, middle parallel planar surface 914, and bottom parallel planar surface 916 and corresponding sides 918, 920 and 922 are similar is all respects to similar surfaces and sides described above and shown in Fig. 4A.

Bottom parallel planar surface 916 of the sensor 902 includes one or more bond pads 926 and one or more bumpers similar in all respects to the bond pads and bumpers described above and shown in Fig. 4A.

Referring to Fig. 9, an alternate embodiment of the sensor package 405 includes the housing 602, the sensor 902, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is coupled to the top of the housing 602. The controller assembly 508 is coupled to the top of the housing 602. The sensor 902 is coupled within the housing 602. This embodiment is the passive/active/passive sensor embodiment of Fig. 8 with a top-mounted controller assembly 508.

Referring to Fig. 10, an alternate embodiment of the sensor package 405 includes the housing 502, the sensor 902, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is coupled to the top of the housing 502. The controller assembly 508 is coupled to the bottom of the housing 502. The sensor 902 is preferably coupled within the housing 502. This embodiment is the passive/active/passive sensor embodiment of Fig. 8 and including the spring-lid combination described above with respect to Fig 6A.

Referring to Fig. 11, an alternate embodiment of the sensor package 405 includes the housing 602, the sensor 902, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is coupled to the top of the housing 602. The controller assembly 508 is coupled to the top of the housing 602. The sensor 902 is coupled within the housing 602. This is the passive/active/passive sensor embodiment of Fig. 9 further including the spring-lid configuration of Fig. 6A.

Referring to Fig. 12, an alternate embodiment of the sensor package 405 preferably includes a housing 1302, a sensor 1304, the lid assembly 506, and

the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 1302. The controller assembly 508 is preferably coupled to the bottom of the housing 1302. The sensor 1304 is preferably coupled within the housing 1302 such that substantially all of the sensor 1304 is an active region.

The housing 1302 is coupled to the sensor 1304, the lid assembly 506, the controller assembly 508, the electrical connections 510. one or more sliding supports 1372, and one or more resilient couplings 1306. The housing includes a cavity 1308, one or more planar surfaces 1310 and a bottom exterior surface 1314. The cavity 1308 includes a first wall 1316, a second wall (not shown), a third wall 1320 and a fourth wall (not shown). The cavity, surfaces, resilient couplings and walls are all substantially as described above with respect to Fig. 4A with only dimensional differences. A detailed description of these differences are not essential to the understanding of this embodiment.

The cavity 1308 includes a bottom surface 1324 similar in most respects to the bottom surface described above and shown in Fig. 4A. The bottom surface 1324 further includes a recess 1326 defined by a first wall 1328, a second wall (not shown), a third wall 1332, a fourth wall (not shown), and a bottom surface 1336. The recess 1326 is located approximately in the center of the bottom surface 1324 of the cavity 1308 of the housing 1302 and may be plated with a metal such as gold for soldering.

The housing 1302 includes first planar surfaces 1310a-d substantially as described with the planar surfaces of Fig. 4A. A first planar surface 1310a preferably includes one or more planar bond pads 1338.

A bottom exterior surface 1314 of the housing 1302 includes a contact pad (not shown), one or more bond pads 1344, and one or more connecting pads (not shown). All substantially as described above with respect to the embodiment of Fig. 4A.

The sensor 1304 is preferably resiliently attached to the housing 1302 by the resilient couplings 1306, slidingly supported at a bottom surface 1358 by the sliding supports 1372 and electrically coupled to the housing 1302 by the electrical connections 510. The sensor 1304 is an entirely active region.

The bond pad 1368 is similar in material to the bond pads described above with respect to Fig. 4A. The bond pad 1368 may be selected from any of several geometrical shapes such as an approximately oct-pie-wedge cross-sectional shape, an approximately hollow oct-pie-wedge cross-sectional shape, an approximately nine-circular cross-sectional shape, an approximately starburst cross-sectional shape, an approximately sunburst cross-sectional shape or any other suitable cross-sectional shape.

In an alternate embodiment, the a resilient coupling 1306 may be two resilient couplings that are substantially equal in size and are vertically proximate to each other. In several alternate embodiments, the sliding supports 1372 may have an approximately rectangular cross-sectional shape. The sliding supports 1372 may have an approximately triangular cross-sectional shape. The sliding supports 1372 may have an approximately circular cross-sectional shape.

Referring to Fig. 13, an alternate embodiment of the sensor package 405 preferably includes a housing 1402, the sensor 1304, the lid assembly 506, and the controller assembly 508. The lid assembly 506 is preferably coupled to the top of the housing 1402. The controller assembly 508 is preferably coupled to the top of the housing 1402. The sensor 1304 is preferably coupled within the housing 1402. This embodiment is the embodiment of Fig. 12 with a top-mounted controller assembly 508. All walls 1412, 1416, 1424, 1428, pads 1434, surfaces 1406, 1420, 1432, cavity 1404, housing 1402 and recess 1422 are all substantially as described above with respect to the embodiments shown in Figs. 4A and 12.

Figs. 14 is an alternate embodiment of the sensor package 405 includes the housing 1302, the sensor 1304, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is coupled to the top of the housing 1302. The controller assembly 508 is coupled to the bottom of the housing 1302. The sensor 1304 is coupled within the housing 1302. This embodiment is the embodiment of Fig. 12 incorporating the spring-lid assembly as described above and shown in Fig. 6A.

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Fig. 15 is an alternate embodiment of the sensor package 405 includes the housing 1402, the sensor 1304, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is coupled to the top of the housing 1402. The controller assembly 508 is coupled to the top of the housing 1402. The sensor 1304 is coupled within the housing 602. This embodiment is the embodiment of Fig. 14, but having a top-mounted controller assembly 508 as described above and shown in Fig. 5A.

Referring to Figs. 16A through 16C, an alternate embodiment of the sensor package 405 includes a housing 1702, a sensor 1704, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is coupled to the top of the housing 1702. The controller assembly 508 is coupled to the bottom of the housing 1702. The sensor 1704 is coupled within the housing 1702.

The packaging of the housing 1702, the sensor 1704, and the lid assembly 702 are the sensor package arrangement substantially as disclosed in copending U. S. Patent Application Serial No. 08/935,093, Attorney Docket No. IOS011, filed on September 25, 1997, the contents of which are incorporated herein by reference. All walls 1716, 1720, pads 1726, 1732,, surfaces 1710, 1714, 1724, 1742, 1744, 1746, cavity 1708, housing 1702, sensor 1704, and sensor members 1736, 1738, 1740 are all substantially as described above with respect to the embodiments shown in Figs. 4A with differences being only in the number and dimensions of the elements.

The sensor 1704 is preferably coupled to the housing 1702 via a spring assembly 1706 and a shorting clip 1748. The spring assembly 1706 is fabricated from one piece of spring material which is bent into a middle spring member 1750, a side spring member 1752 and a side support member 1754. The middle spring member 1750 is approximately perpendicular to both the side spring member 1752 and the side support member 1754. The middle spring member 1750 has a flat top surface 1756 that curls down to a loop 1758. The side spring member 1752 has a flat top surface 1760 that curls down to a loop 1762. The side support member 1754 has a flat top surface 1764 that bends down at a right angle.

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The spring assembly 1706 is inserted into the cavity 1708. The middle spring member 1750 flat top surface 1756, the side spring member 1752 flat top surface 1760, and the side support member 1754 flat top surface 1764 are coupled to the third planar surface 1710c of the housing 1702. In one embodiment, the spring assembly 1706 is welded to the third planar surface 1710c of the housing 1702 to provide mechanical and electrical connection to the sensor 1704. The middle spring member 1750 loop 1758 and the side spring member 1752 loop 1762 secure the sensor 1704 within the cavity 1708 of the housing 1702.

The shorting clip 1748 extends around the first middle planar surface 1744 of the sensor 1704 and the second middle planar surface 1746 of the sensor 1704. The shorting clip 1748 contacts the spring assembly 1706 securing the sensor 1704 within the cavity 1708 of the housing 1702 providing a conductive pathway between the center member 1738 of the sensor 1704, to the third planar surface 1710c of the housing 1702. The shorting clip 1748 may be fabricated using stainless steel or beryllium copper strip. Using stainless steel for the shorting clip 1748 provides good mechanical strength and stable properties.

Fig. 17 is an alternate embodiment of the sensor package 405 includes a housing 1802, the sensor 1704, the lid assembly 702, and the controller assembly 508. The lid assembly 702 is coupled to the top of the housing 1802. The controller assembly 508 is coupled to the top of the housing 1802. The sensor 1704 is coupled within the housing 1802. This embodiment is the embodiment of Fig. 16A having a top-mounted controller assembly 508.

Referring to Fig. 18, an alternate embodiment of the sensor module 305 includes the sensor packages 405, a substrate 410, and a monolithic package 1902. The sensor packages 405 are coupled to the monolithic package 1902. In one embodiment, the sensor module 305 includes a first sensor package 405a, a second sensor package 405b, and a third sensor package 405c. The first sensor package 405a includes an axis of sensitivity 415. The axis of sensitivity 415 is approximately parallel to the x-axis. The first sensor package 405a is coupled to the monolithic package 1902 to maintain the axis of sensitivity 415 parallel

to the x-axis. The second sensor package 405b includes an axis of sensitivity 420. The axis of sensitivity 420 is approximately parallel to the y-axis. The second sensor package 405b is coupled to the monolithic package 1902 to maintain the axis of sensitivity 420 parallel to the y-axis. The third sensor package 405c includes an axis of sensitivity 425. The axis of sensitivity 425 is approximately parallel to the z-axis. The third sensor package 405c is coupled to the monolithic package 1902 to maintain the axis of sensitivity 425 parallel to the z-axis.

The sensor packages 405 may be coupled to the monolithic package 1902 using one of the following methods: integrated as part of the monolithic package 1902, rigidly attached to the monolithic package 1902, or removably attached to the monolithic package 1902. In one embodiment, the sensor packages 405 are coupled to the monolithic package 1902 by removably attaching the sensor packages 405 into the monolithic package 1902 for cost-effectiveness and good manufacturability. In several alternate embodiments, the removable attachment methods include socketing, screw attaching or other mechanical attachment methods.

The monolithic package 1902 may be plastic, ceramic, or metal. In one embodiment, the monolithic package 1902 is plastic to provide ease of manufacturing and cost effectiveness. The monolithic package 1902 may be a hollow frame, a box, a three-dimensional circuit board, a cylinder, or a cube. The monolithic package 1902 is coupled to the substrate 410. The monolithic package 1902 may be coupled to the substrate 410 using one of the following methods: solder-paste surface mount, solder-ball, leads, connectors, epoxies, mechanical connections or wire bonding. The monolithic package 1902 is coupled to the substrate 410 by leads to provide cost effectiveness and good manufacturability.

In several alternate embodiments, rigidly attaching the sensor packages 405 to the monolithic package 1902 includes using solder, epoxies, or glass frit bonding.

In several alternate embodiments, the monolithic package 1902 includes recesses adapted to receive the sensor packages 405.

In several alternate embodiments, the sensor packages 405 may be the sensors 504, 902, 1304, or 1704 as described above with reference to Figs. 4A, 8,12 and 16A. The sensors 504, 902, 1304, or 1704 may be coupled to the monolithic package 1902 by methods substantially as described above in any of the preceding embodiments. In an alternate embodiment, the sensors 504, 902, 1304, or 1704 are further vacuum-sealed into the monolithic package 1902.

Referring to Fig. 19, an alternate embodiment of the sensor module 305 includes one or more sensor packages 405. The sensor packages 405 are coupled to each other. In one embodiment, the sensor module 305 includes the first sensor package 405a, the second sensor package 405b, and the third sensor package 405c. The first sensor package 405a includes an axis of sensitivity 415. The axis of sensitivity 415 is approximately parallel to the x-axis. The first sensor package 405a is coupled to the second sensor package 405b to maintain the axis of sensitivity 415 parallel to the x-axis. The second sensor package 405b includes an axis of sensitivity 420. The axis of sensitivity 420 is approximately parallel to the y-axis. The second sensor package 405b is coupled to the first sensor package 405a and the third sensor package 405c to maintain the axis of sensitivity 420 parallel to the y-axis. The third sensor package 405c includes an axis of sensitivity 425. The axis of sensitivity 425 is approximately parallel to the z-axis. The third sensor package 405c is coupled to the second sensor package 405b to maintain the axis of sensitivity 425 parallel to the z-axis. The sensor packages 405 may be coupled to each other using one of the following methods: solder, epoxy, or mechanical attachment. In one embodiment the sensor packages 405 are coupled to each other by solder for good manufacturability.

Referring to Figs. 20A through 20C, in an alternate embodiment, the sensor package 405 includes one or more substrates 2102 and one or more sensors 2118. The substrates 2102 are coupled to the sensors 2118.

The substrates 2102 may be ceramic, PC-board or silicon. In one embodiment, there is a single substrate 2102. The substrate 2102 includes a top planar surface 2128 and a bottom planar surface 2130. The top planar surface 2128 includes one or more traces 2104. The bottom planar surface

includes one or more traces 2104. The traces 2104 may be aluminum, copper or gold. In one embodiment, the traces 2104 are gold for conductivity and solder interconnection. The number of traces 2104 depends on having sufficient traces 2104 to couple the sensor 2118 to the package 2102.

The substrate 2102 further includes one or more slots 2106. The slots 2106 include a first wall 2108, a second wall 2110, a third wall 2112, and a fourth wall 2114. The first wall 2108 and the third wall 2112 are approximately parallel to each other and the second wall 2110 and the fourth wall 2114 are approximately parallel to each other. The second wall 2110 and the fourth 2114 wall are also perpendicular to the first wall 2108 and the third wall 2112. The slots 2106 are adapted to receive the sensors 2118. The length of the slot L_{2106} may range, for example, from about 5000 to 15000 microns. In one embodiment, the length of the slot L_{2106} ranges from about 5000 to 7000 microns to facilitate vertical alignment. The width of the slot W_{2106} may range, for example, from about 500 to 2000 microns. In one embodiment, the width of the slot W_{2106} ranges from about 1000 to 1200 microns to facilitate vertical alignment.

The sensors 2118 are coupled to the substrate 2102. The sensors 2118 have an approximately rectangular cross-sectional shape. In one embodiment, the sensors 2118 includes a first member 2120, a second member 2122, and a third member 2124. The first member 2120 is on top of the second member 2122 and the second member 2122 is on top of the third member 2124. In one embodiment, the first member 2120, the second member 2122, and the third member 2124 are a micro machined sensor substantially as described above.

The sensors 2118 further include an axis of sensitivity 2132. The sensors 2118 are coupled to substrate 2102 to maintain the axis of sensitivity 2132 parallel to the substrate 2102. The second member 2122 has an extended tab 2116. The extended tab 2116 is adapted to insert into the slots 2106 of the substrate 2102. The sensors 2122 are resiliently coupled to the substrate 2102 by one or more connections 2126. The connections 2126 may be micro-welding, solder pastes or conductive adhesive. In one embodiment, the connections 2126 are solder paste for tensile strength. The solder pastes 2126 may be eutectic or

non-eutectic. In one embodiment, the solder pastes 2126 are eutectic to provide temperature hierarchy and tensile strength. The solder pastes 2126 couple one or more traces 2104 to the sensor 2122. In one embodiment, there is a first trace 2104a, a second trace 2104b, a third trace 2104c and a fourth trace 2104d. The first trace 2104a is located on the top planar surface 2128 and is coupled to the first member 2120. The second trace 2104b is located on the top planar surface 2128 and is coupled to the third member 2124. The third trace 2104c may be a redundant connection to the second member 2122 or not used. The fourth trace 2104d is located on the bottom planar surface 2130 and is coupled to second member 2122.

Referring to Fig. 20D, in an alternate embodiment, the sensor package 405 as referenced to in Figs. 20A through 20C, includes a first substrate 2102a and a second substrate 2102b. The second substrate includes a top planar surface 2154 and a bottom planar surface 2156. The third trace 2104c and the fourth trace 2104d may be coupled to the second substrate 2102b, for example, by solder paste, conductive epoxy, or wafer bonding techniques. The fourth trace 2104d may be located on the top planar surface 2154 of the second substrate 2102b or on the bottom planar surface 2130 of the first substrate 2102a. The fourth trace 2104d couples the second member 2122 to a bond pad 2150. The bond pad 2150 may be coupled to a bond wire 2152. The sensor package 405 may be surface or flush mounted. The sensor 2118 has one or more leads coming from the first member 2120 and the third member 2124. The substrate 2102b acts like a mechanical spacer.

Referring to Figs. 21A through 21D, in several alternate embodiments, the housings 502, 602, 1302, and 1402, as described above with reference to Figs. 4A, 5A, 12 and 13, include one or more pedestals 2202a or 2202b for supporting one or more resilient couplings. The pedestals 2202a and 2202b may be fabricated from, for example, tungsten or ceramic. In one embodiment, the pedestals 2202a and 2202b are fabricated from ceramic. The height H_{2202} of the pedestals 2202a and 2202b may range, for example, from about 0 to 10 mils. In one embodiment, the height H_{2202} of the pedestals 2202a and 2202b is approximately 5 mils. The pedestal 2202a is a rectangular shaped support pipe

having straight ed[illegible] In an alternate embodiment, th[illegible]destal 2202b is a cylindrical section having tapered sides. In an alternate embodiment, the pedestal 2202b has straight sides. In one embodiment, the pedestals 2202a and 2202b have a shape selected to reduce the thermal stresses between the pedestals 2202a and 2202b and the resilient couplings it supports.

Referring to Figs. 22A and 22B, in an alternate embodiment, the sensor module 305 includes the substrate 2102 and one or more sensors 2118. In one embodiment, there is a first sensor 2118a, a second sensor 2118b, and a third sensor 2118c. The first sensor 2118a and the second sensor 2118b are inserted into one or more slots 2106 and resiliently coupled to the substrate 2102 by one or more solder pastes 2126 as previously described above with reference to Figs. 20A through 20D. The third sensor 2118c is resiliently coupled to the substrate 2102 using any of the resilient couplings 512, 904 or 1306 as described above. The third sensor 2118c is also slidingly supported by the sliding supports 514, 940, or 1372 as described above. In an alternate embodiment, the sliding supports 514, 940, or 1372 are optional.

Referring to Fig. 23, in several alternate embodiments of the sensor package 405, the housings 502, 602, 1302, 1402, 1702 and 1802, as described above, further include a cavity 2402 adapted to receive the controller 582. The housings 502 and 1302 further include one or more external planar surfaces 2404. In one embodiment, there is a first external planar surface 2404a, a second external planar surface 2404b, and a third external planar surface 2404c. The second external planar surface 2404b includes the bond pads 540, 622, 1344, and 1434 as described above. The cavity 2402 includes a first wall 2406a, a second wall 2406b, a third wall 2406c, and a fourth wall 2406d. The first wall 2406a and the third wall 2406c are approximately parallel to each other and the second wall 2406b and the fourth wall 2406d are approximately parallel to each other. The second wall 2406b and the fourth wall 2406d are also perpendicular to the first wall 2406a and the third wall 2406c. The controller 582 may be coupled to the third external planar surface 2404c, for example, by solder or epoxy. The wire bonds 584 couple the controller 582 to the second external planar surface 2404b. A lid 2408 encloses the controller

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582, the wire bonds 584, and the cavity 2402. The lid 2408 is coupled to the first external planar surface 2404a. The lid 2408 includes solder preforms 2410. The solder preforms 2410 are coupled to the first external planar surface 2404a using conventional soldering equipment and processes.

Referring to Figs. 24A and 24B, in several alternate embodiments, the controller assembly 508 includes the adhesive 580, the controller 582, the wire bonds 584, and a hermetic cap 2502. The hermetic cap 2502 may be ceramic or metal. In one embodiment, the hermetic cap 2502 is metal to provide good hermetic sealing. The hermetic cap 2502 is coupled to the housings 502, 602, 1302, 1402, 1702 and 1802 as described above. The hermetic cap 2502 may be press-fit, epoxied, soldered or seam-sealed to the housings 502, 602, 1302, 1402, 1702 and 1802. In one embodiment, the hermetic cap 2502 is soldered to the housings 502, 602, 1302, 1402, 1702 and 1802 to provide good hermetic sealing.

Referring to Figs. 25A and 25B, in an alternate embodiment, the sensor package 405 includes the controller 582 coupled to the housings 502, 602, 1302, 1402, 1702 and 1802, as described above by one or more connections 2602. The connections 2602 may be leads, solder, conductive epoxy, or ball-grid arrays. The controller 582 is an integrated chip industry-standard package such as ceramic or plastic.

Referring to Figs. 26A and 26B, in an alternate embodiment, the sensor package 405 includes a substrate 2702. The controller 582 is coupled to the substrate 2702. The substrate 2702 is coupled to the controller 582 by one or more electrical attachments 2704. The substrate 2702 may be ceramic or organic. The substrate 2702 is also coupled to the housings 502, 602, 1302, 1402, 1702, and 1802, as described above by one or more electrical attachments 2704. The electrical attachments 2704 may be leads, solder, conductive epoxy, or ball grid arrays. The controller 582 may be an application specific integrated circuit die or an integrated chip industry standard package with connections. The integrated chip industry standard package may be ceramic or plastic. The solder attachments 2704 may be, for example, leads, solder, conductive epoxy, or ball-grid arrays. The substrate 2702 further includes conventional leads, connectors or solder joints.

In an alternate embodiment, the substrate 2702 further includes circuit components. The circuit components may be, for example, filtering capacitors, resistors, or active components. In one embodiment, the circuit components are filtering capacitors to provide reduced system 100 size.

In several alternate embodiments, the housings 502 and 602, as described above with reference to Figs. 4A and 5A, include one or more recesses 1326, for receiving one or more resilient couplings substantially as described above with reference to Fig. 12.

In several alternate embodiments, the cavities 516, 604, 1308, 1404, 1708, and 1804, as described above may be further filled with other materials such as gels or molded plastics.

In several alternate embodiments, splitting the resilient attachment of the sensor 504, 902, and 1304, as described above with reference to Figs. 4A, 8, and 12, to the housing 502, 602, 1302, and 1402, as described above with reference to Figs. 4A, 5A, 12, and 13, reduces the stress from the attachment.

In several alternate embodiments, the resilient couplings 512, 904, and 1306, as described above with reference to Figs. 4A, 8 and 12, are split into one or more pieces by splitting solder preform, conductive epoxy, non-conductive epoxy, or glass frit. The splitting may be done by any conventional splitting method.

In several alternate embodiments, the resilient couplings 512, 904, and 1306 as described above with reference to Figs. 4A, 8 and 12, further electrically couple the respective sensors 504, 902, and 1304 to the housings 502, 602, 1302, and 1402, as described above with reference to Figs. 4A, 8, 12, and 13.

In several alternate embodiments, the housings 502 ,602, 1302, and 1402, as described above with reference to Figs. 4A, 5A, 12, and 13, are any conventional substrate.

In several alternate embodiments, the sensor packages 405 size is reduced by vertically stacking the components of the sensor packages 405.

In several alternate embodiments, the sensor packages 405 performance is improved by reducing the communication path length between the controller

assembly 508 and [illegible] sensors 504, 902, and 1304, as substantially described above with reference to Figs. 4A through 26B. The performance improvement may be reduced parasitic capacitance, resistance, or inductance.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. A sensor apparatus comprising;
a housing including a cavity;
a first end cap on one end of the housing;
a second end cap on an opposite end of the housing;
a sensor module coupled to the first end cap and supported within the housing cavity, including a plurality of sensor packages, each sensor package having an axis of sensitivity positioned in a different spatial direction;
a plurality of first sealing members for sealing the interface between the first end cap and the housing;
a plurality of second sealing members for sealing the interface between the second end cap and the housing;
a plurality of first coupling members for coupling the first end cap to the housing; and
a plurality of second coupling members for coupling the second end cap to the housing.

2. A sensor package comprising;
a package; and
a sensor coupled to the package.

3. A sensor assembly package, comprising;
a plurality of sensor packages, each sensor package having an axis of sensitivity; and
wherein each sensor package is positioned with its axis of sensitivity in a different spatial direction.

4. A method of coupling a controller onto a package, comprising; dispensing an adhesive on the package;
placing the controller onto the adhesive;

curing the adhesive;
wire-bonding the controller to the package; and
encapsulating the controller and the wire bonds.

5. A method of assembling a sensor package including a package and a sensor, comprising coupling the sensor to the package.

6. A method of assembling a multi-axis sensor assembly, comprising:
a plurality of sensor packages, each sensor package having an axis of sensitivity; and
positioning each sensor package with its axis of sensitivity in a different spatial direction.

7. A sensor module package comprising;
one or more substrates including one or more slots; and
one or more sensors positioned within the slots.

8. A method of assembling a sensor package comprising one or more substrates and one or more sensors, comprising coupling the sensor to the substrates.

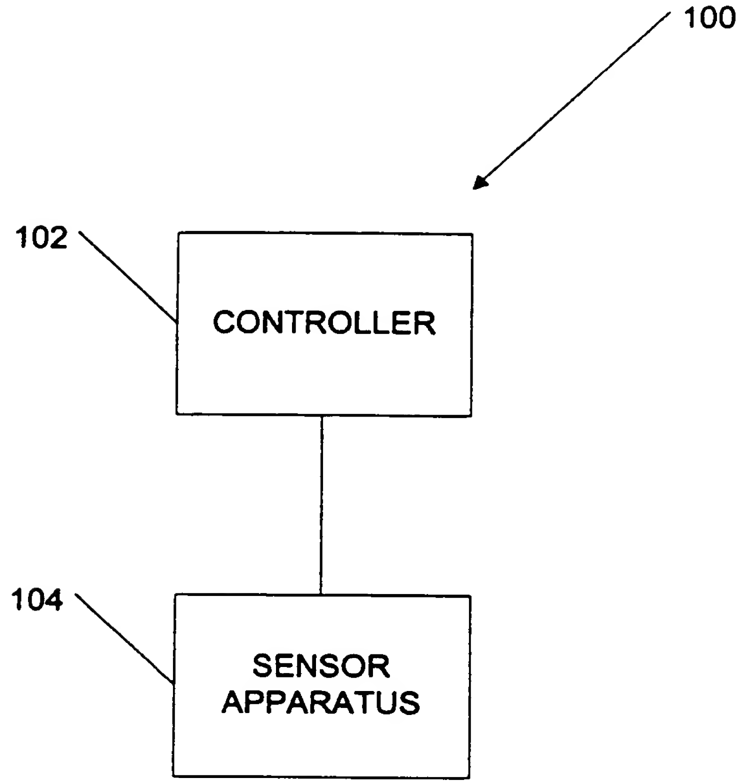

FIGURE 1

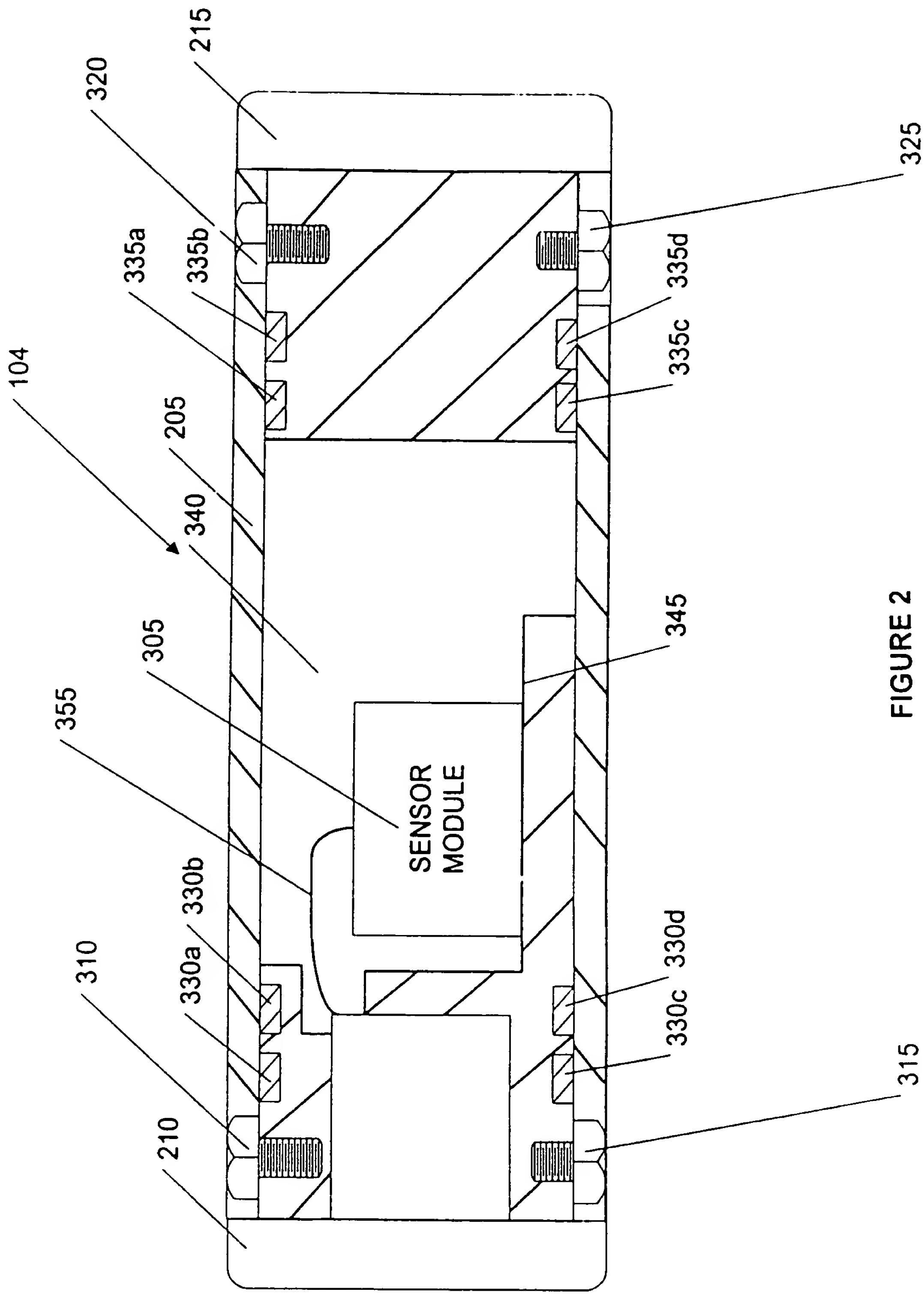
215
320
325
335a
335b
335d
335c
104
205
340
345
305
355
SENSOR MODULE
330b
330d
310
330a
330c
315
210

FIGURE 2

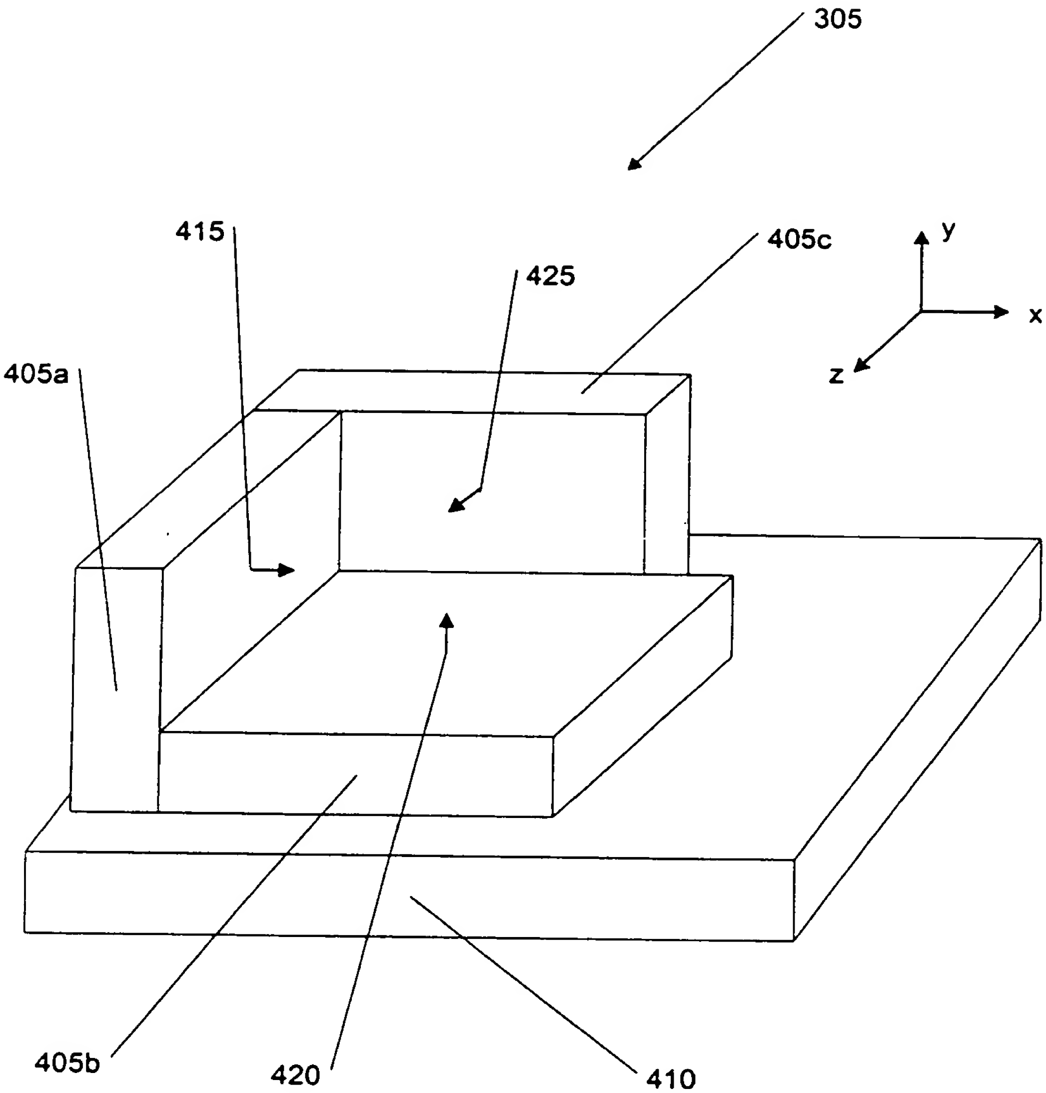

FIGURE 3

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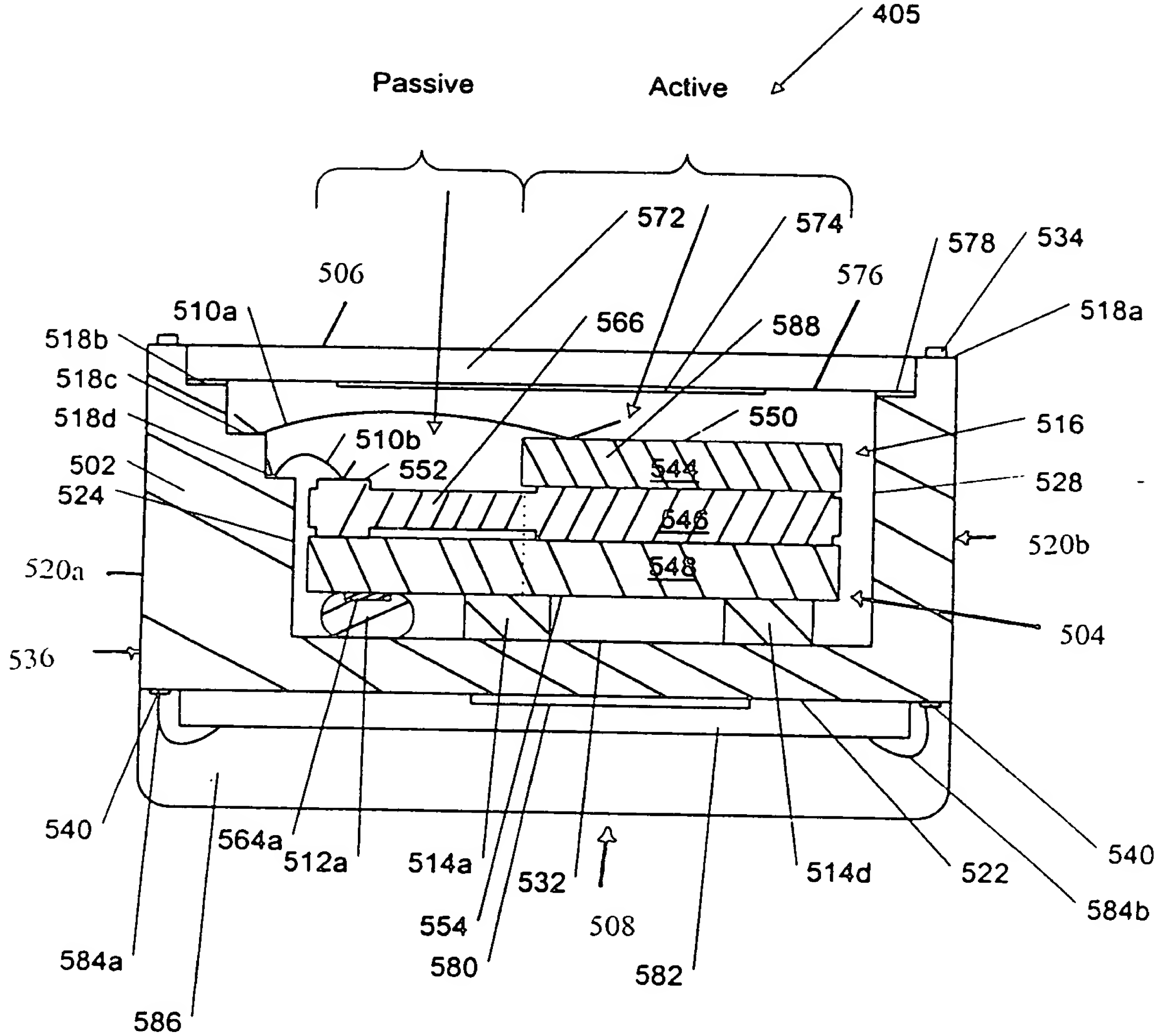
405
Passive
Active
572
574
578
534
506
576
518a
510a
566
588
518b
518c
550
516
518d
510b
502
552
544
528
524
546
520b
520a
548
504
536
540
564a
512a
514a
532
514d
522
540
584b
554
508
584a
580
582
586

FIGURE 4A

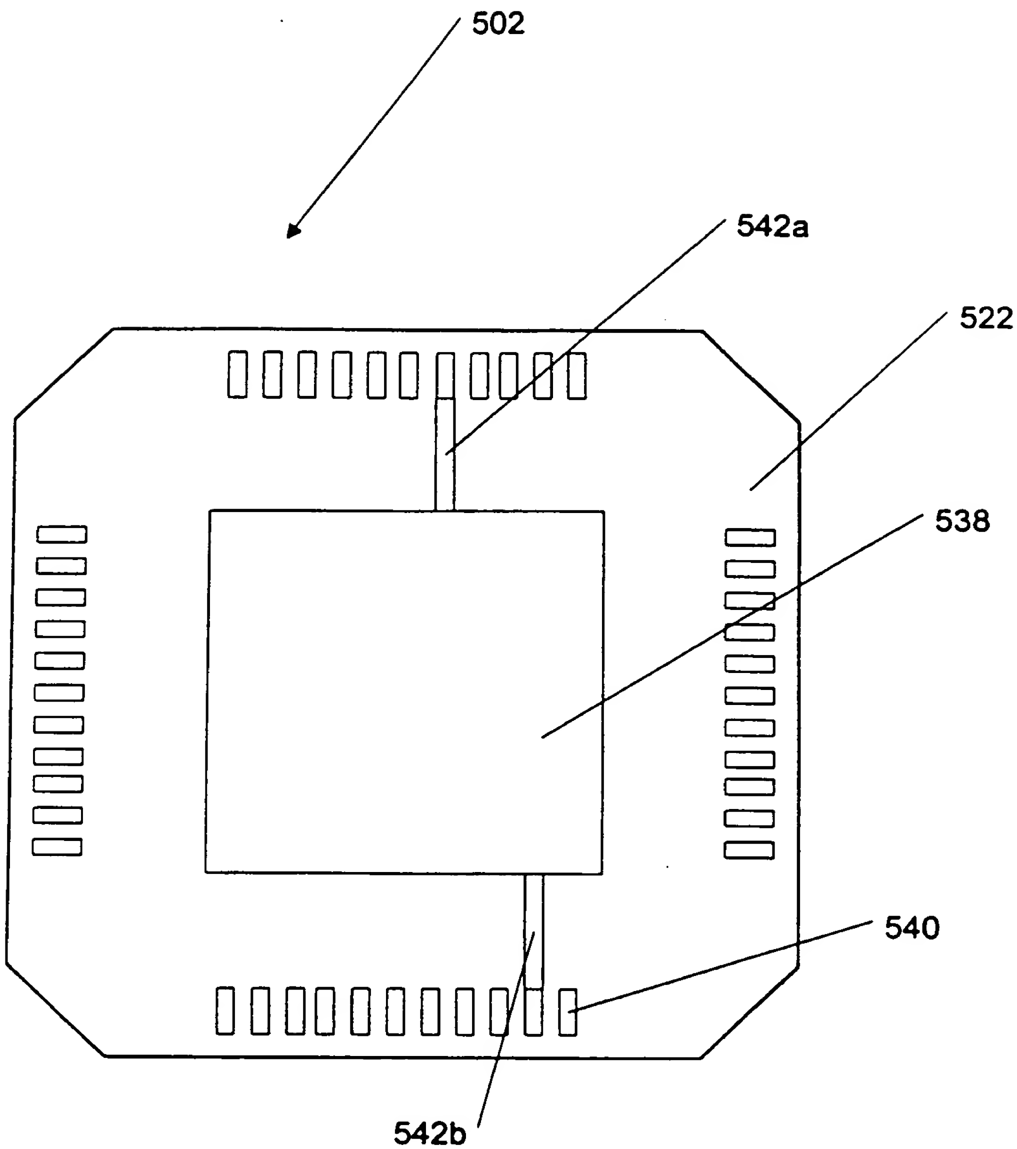

FIGURE 4B

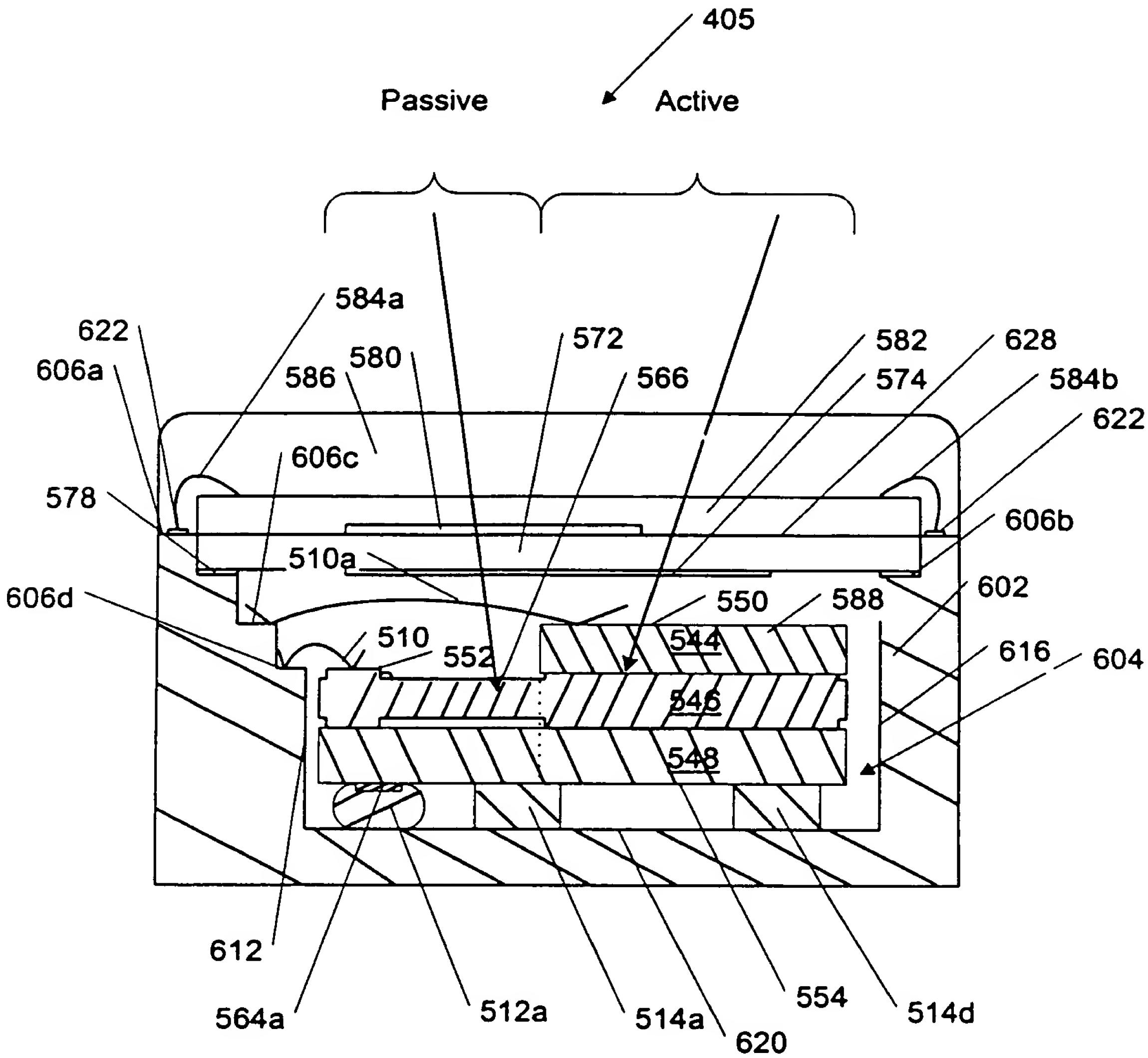
405
Passive
Active
584a
622
572
582
628
606a
586
580
566
574
584b
622
606c
578
606b
510a
602
606d
550
588
544
616
604
510
552
546
548
612
564a
512a
514a
620
554
514d

FIGURE 5A

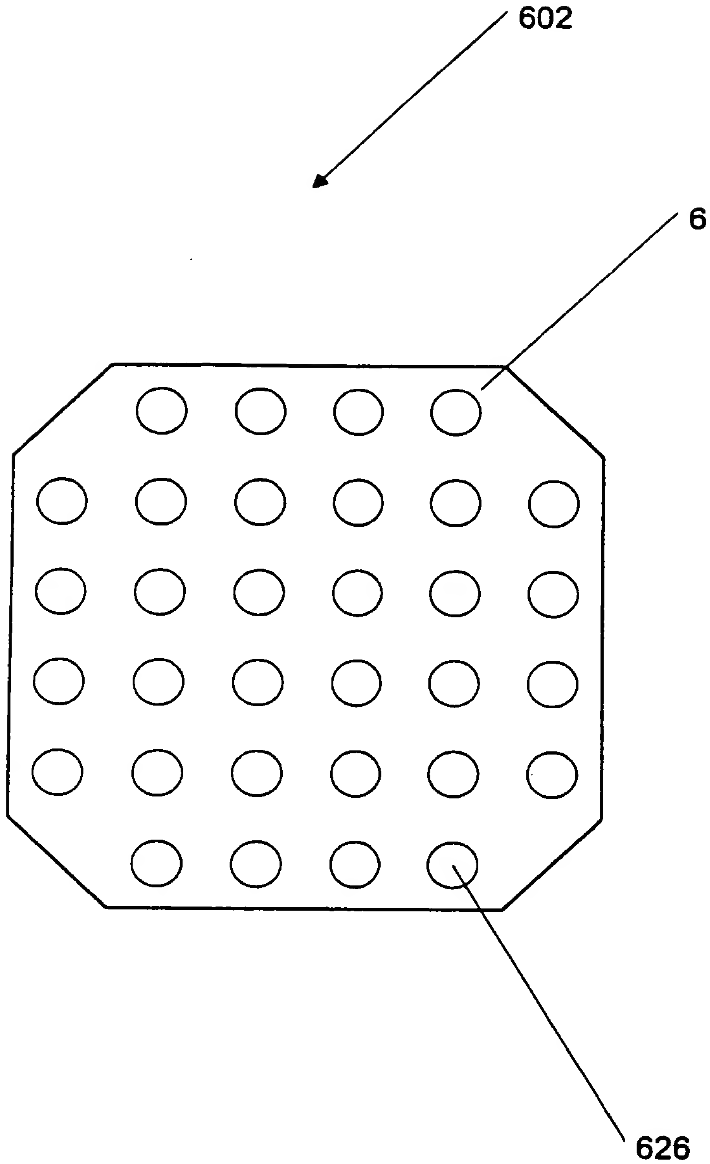

FIGURE 5B

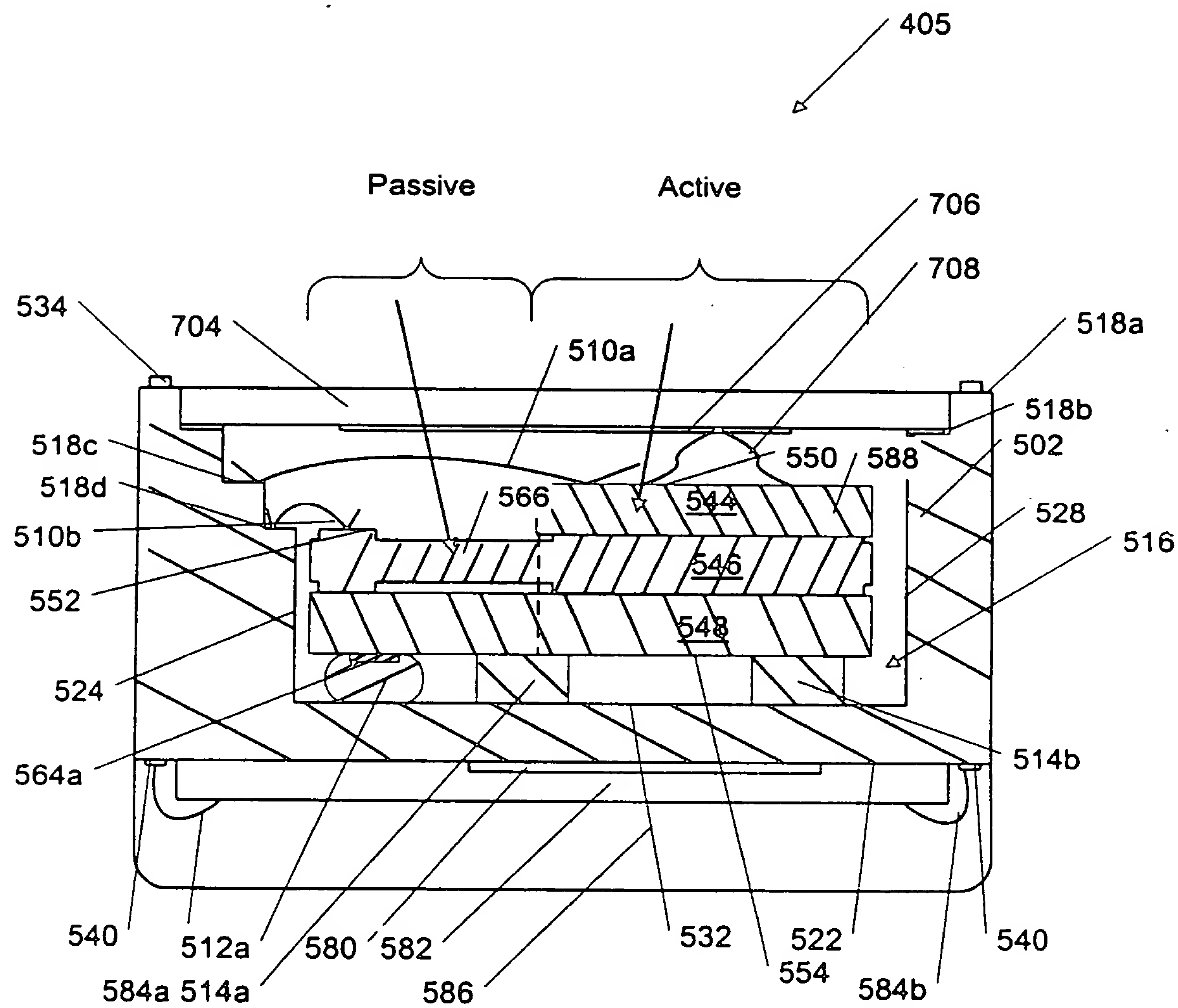
405
Passive
Active
706
708
534
704
518a
510a
518b
518c
550
588
502
518d
566
544
528
510b
546
516
552
548
524
564a
514b
540
512a
580
582
532
522
540
584a
514a
586
554
584b

FIGURE 6A

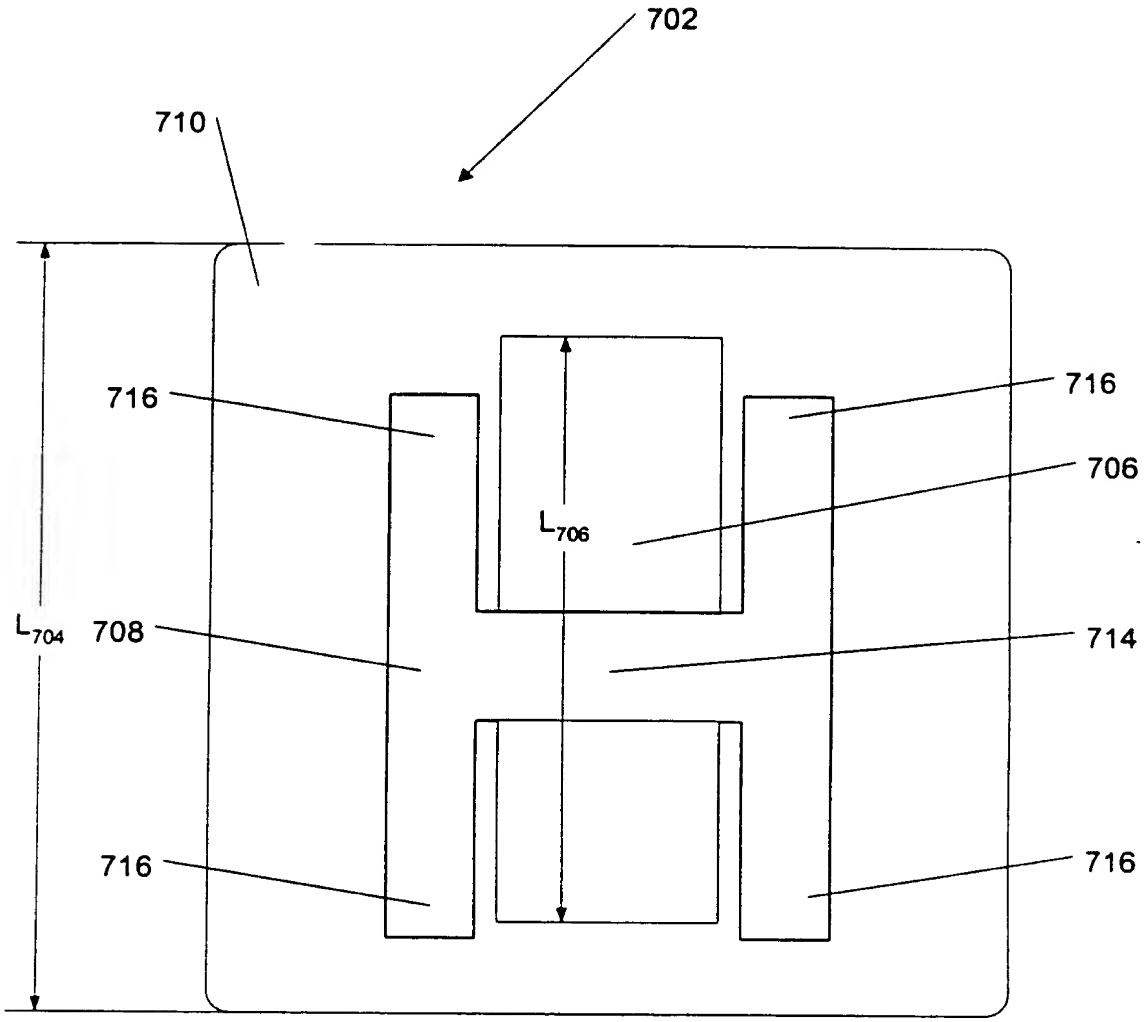

FIGURE 6B

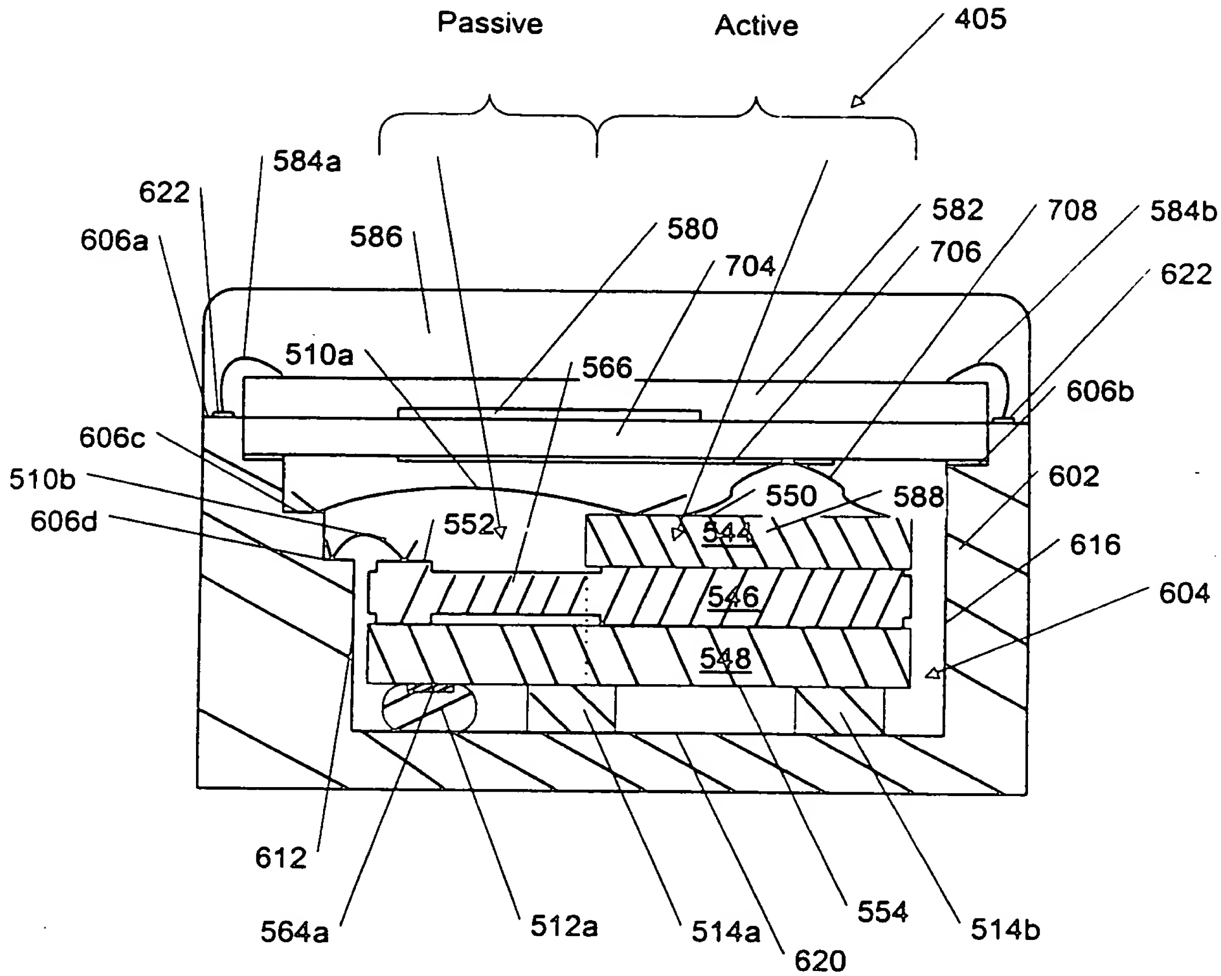
Passive
Active
405
584a
622
606a
586
580
704
582
706
708
584b
622
510a
566
606b
606c
510b
606d
550
552
588
544
602
616
546
548
604
612
564a
512a
514a
620
554
514b

FIGURE 7

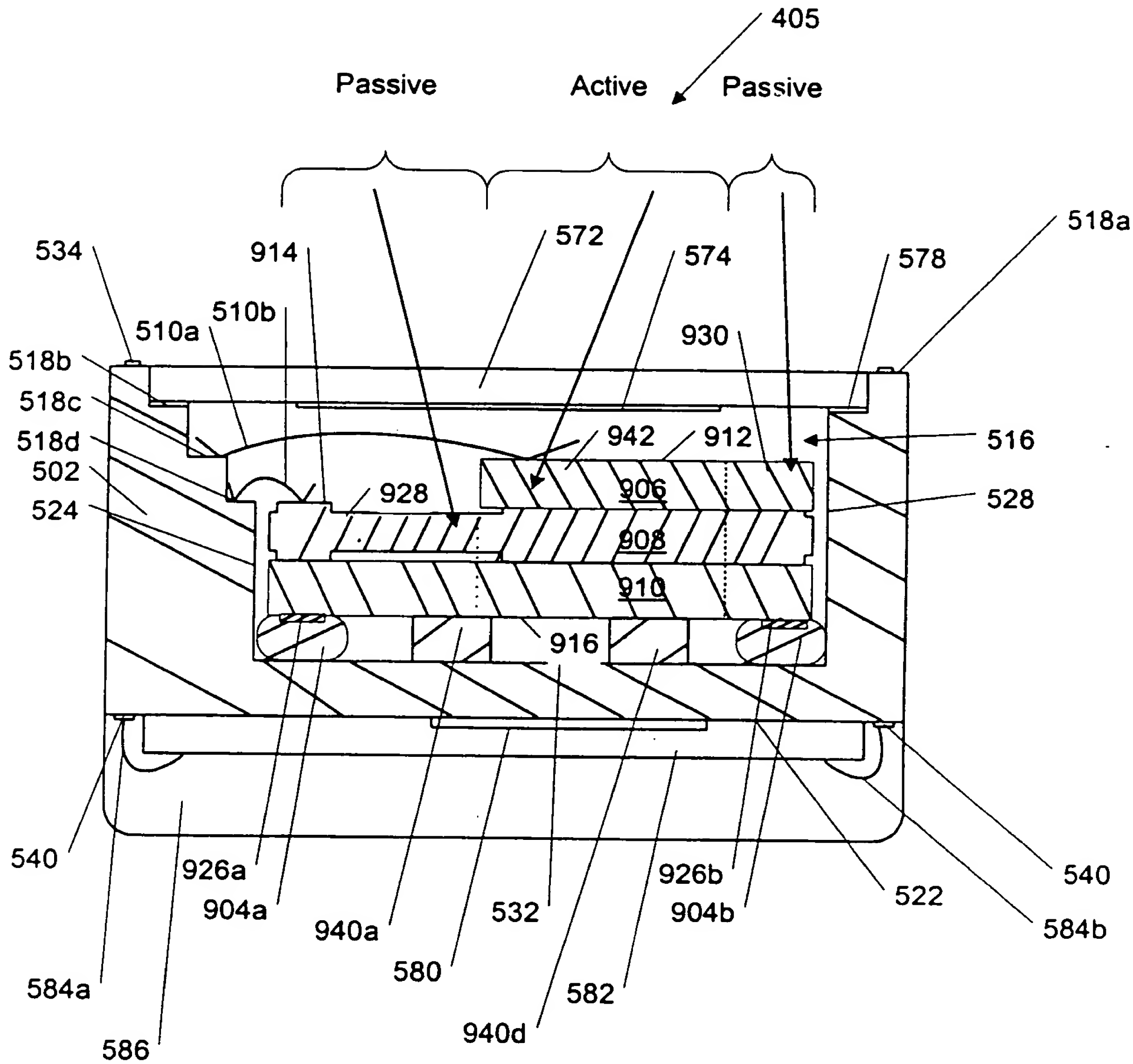

FIGURE 8

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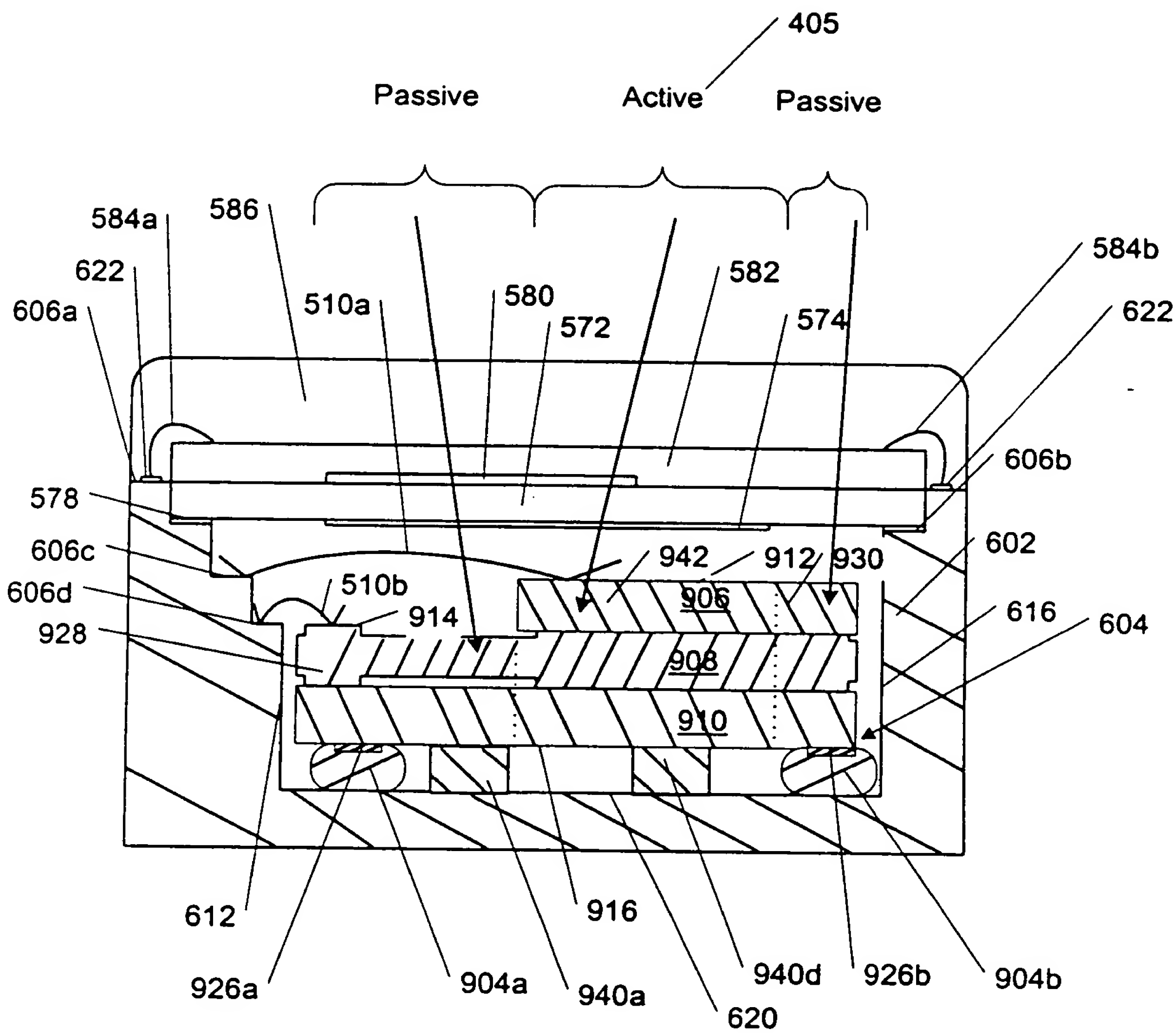
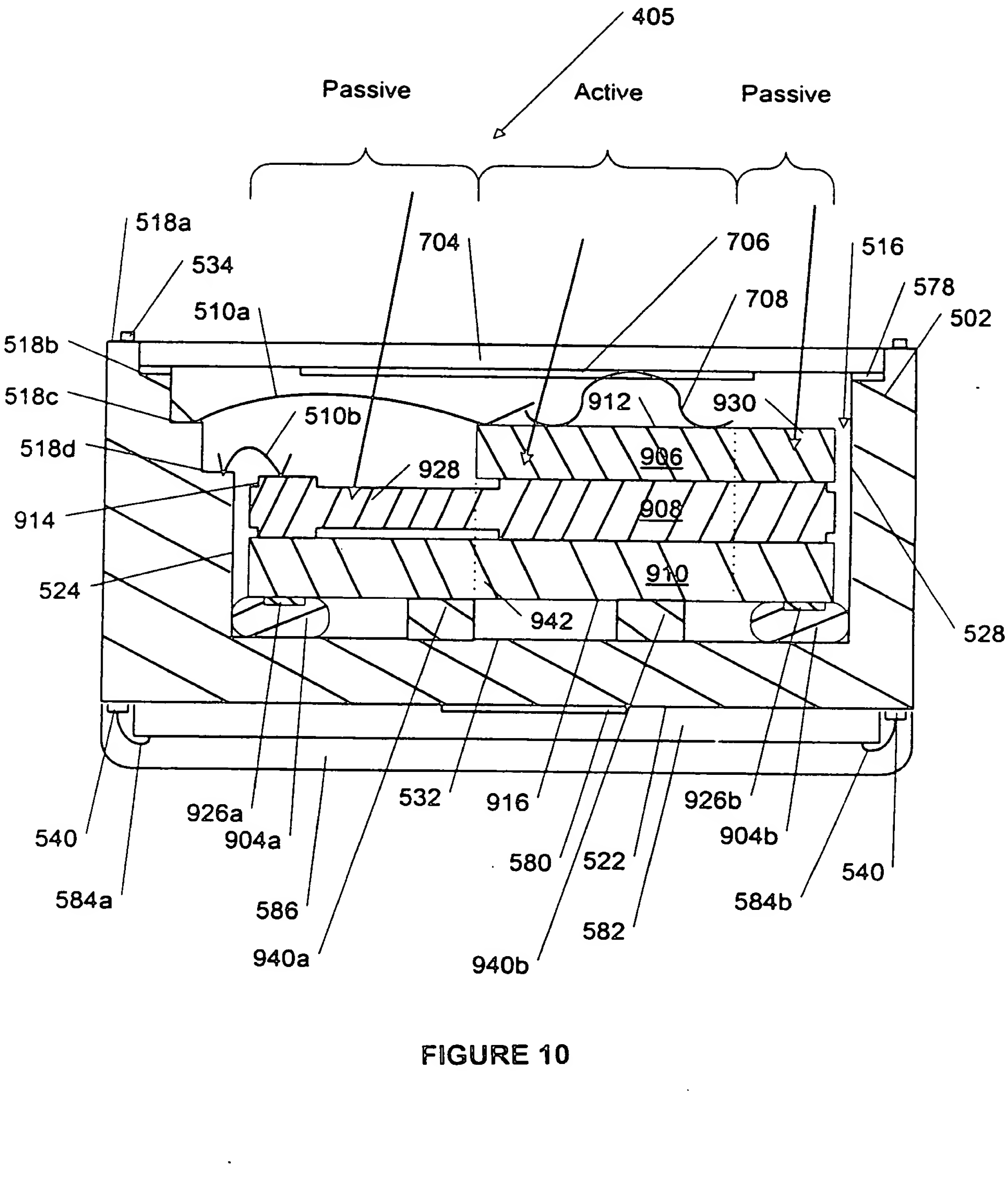

405
Passive
Active
Passive
584a
586
622
606a
510a
580
572
582
574
584b
622
606b
578
606c
606d
928
510b
914
942
912
930
906
908
910
602
616
604
612
926a
904a
940a
916
620
940d
926b
904b

FIGURE 9



405
Passive
Active
Passive
518a
534
704
706
516
578
510a
708
502
518b
518c
912
930
510b
518d
906
928
914
908
524
910
528
942
532
916
926b
926a
540
904a
904b
580
522
540
584a
586
584b
582
940a
940b

FIGURE 10

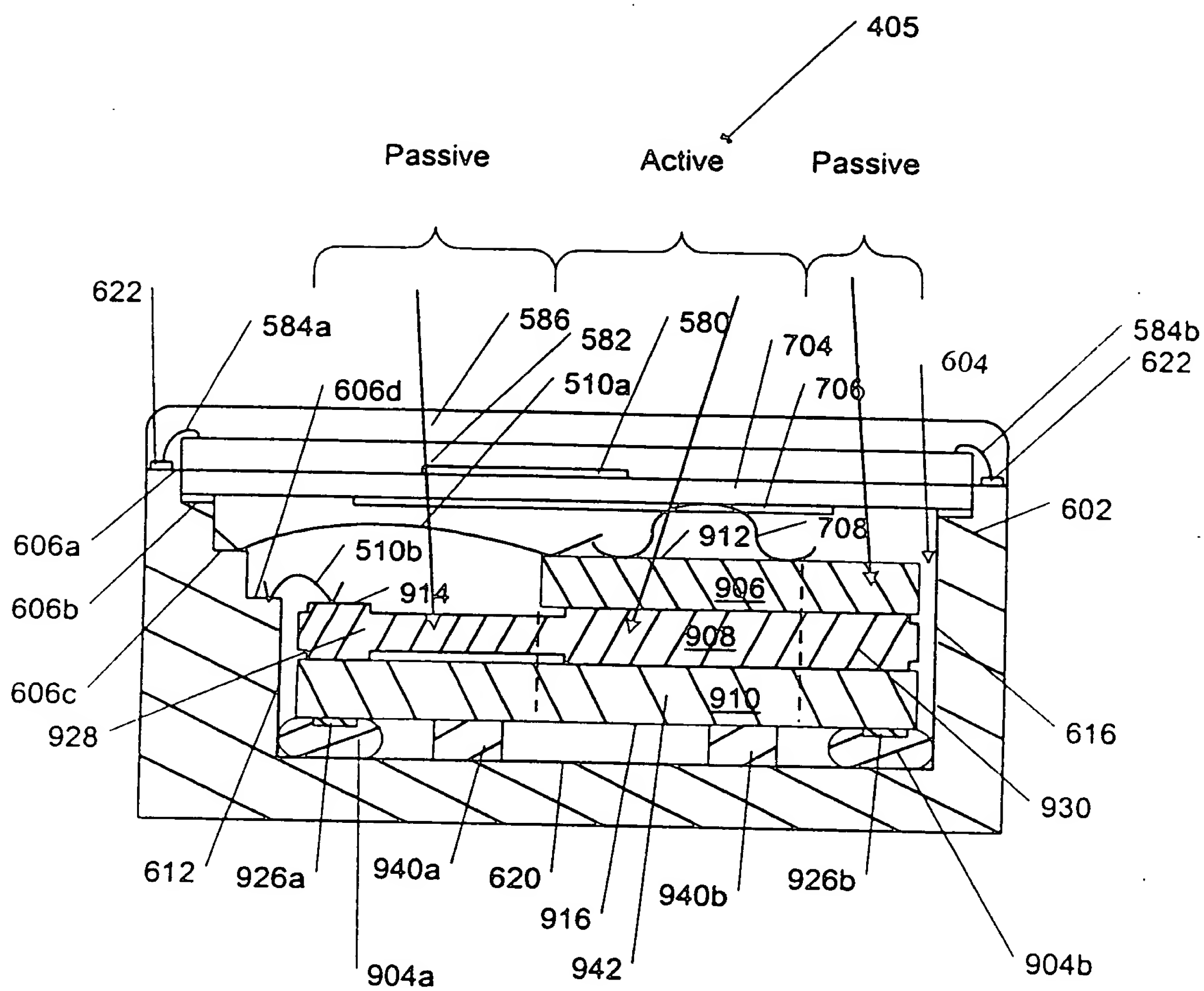


FIGURE 11

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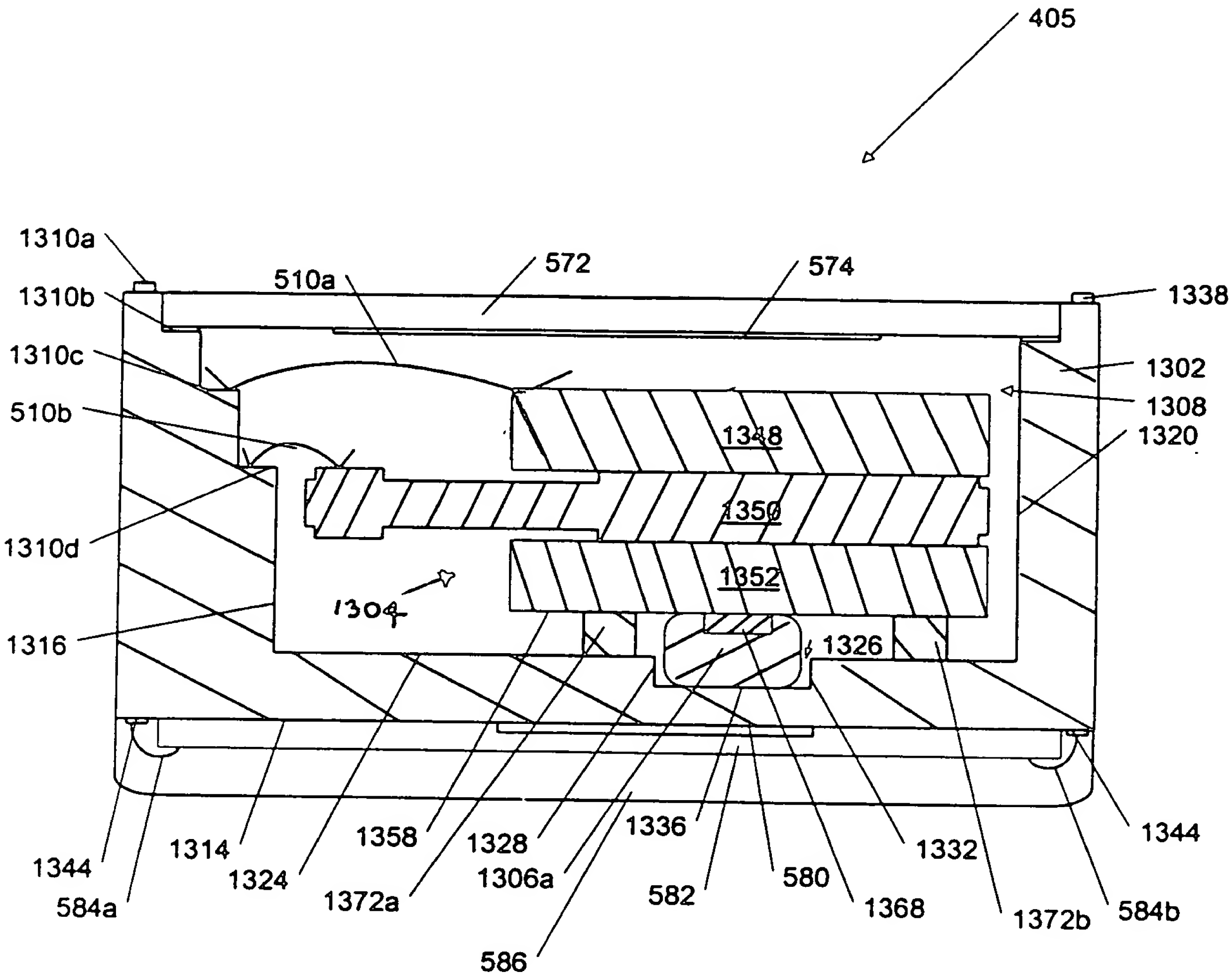
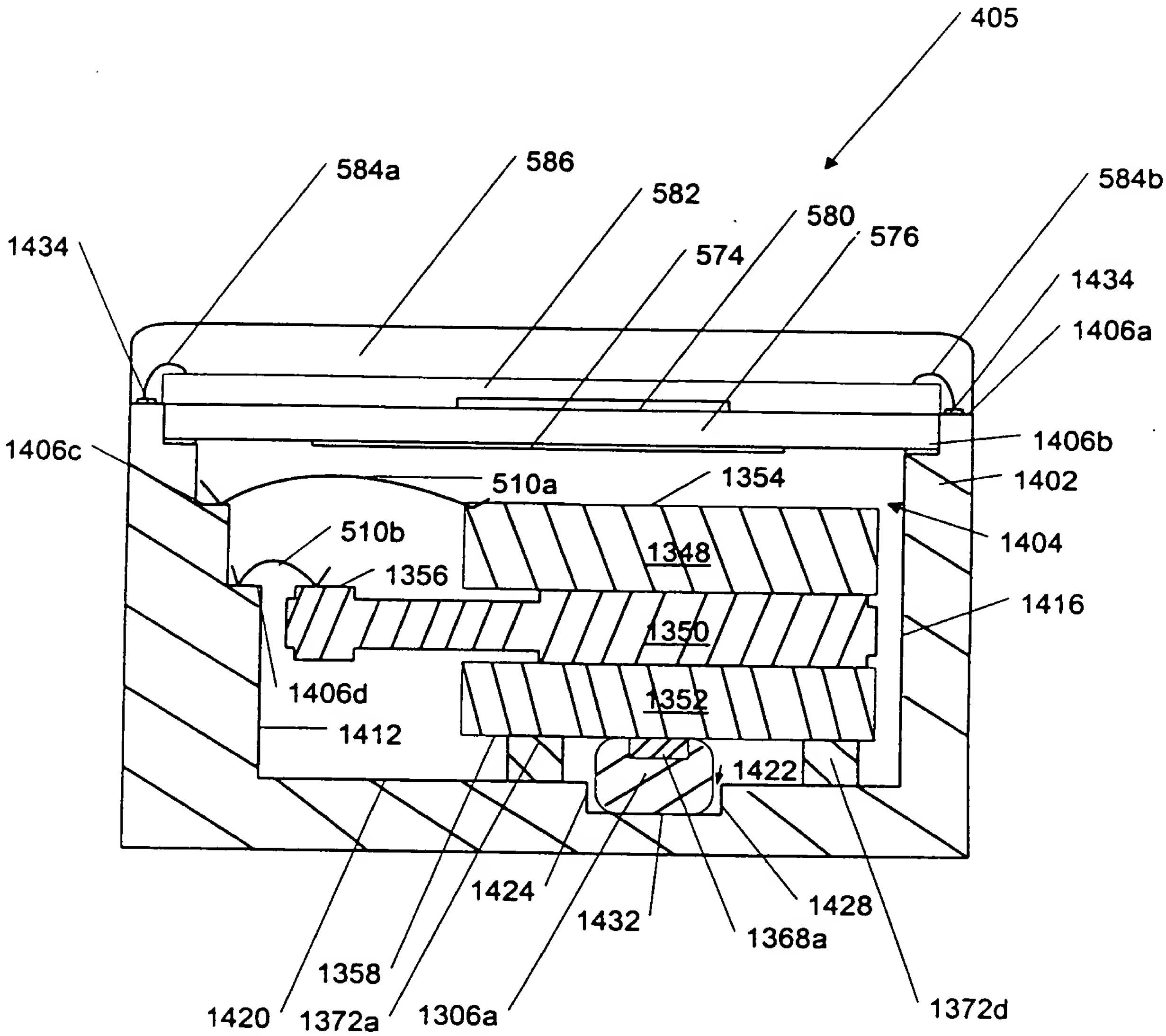

405
1310a
572
574
510a
1310b
1338
1310c
1302
1308
510b
1348
1320
1350
1310d
1352
1304
1316
1326
1344
1314
1358
1328
1336
1332
1344
1324
1372a
1306a
582
580
1368
1372b
584b
584a
586

FIGURE 12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584a
586
582
580
576
574
584b
1434
1434
1406a
1406b
1406c
510a
1354
1402
1404
510b
1356
1348
1416
1350
1406d
1352
1412
1422
1424
1428
1432
1368a
1358
1420
1372a
1306a
1372d

FIGURE 13

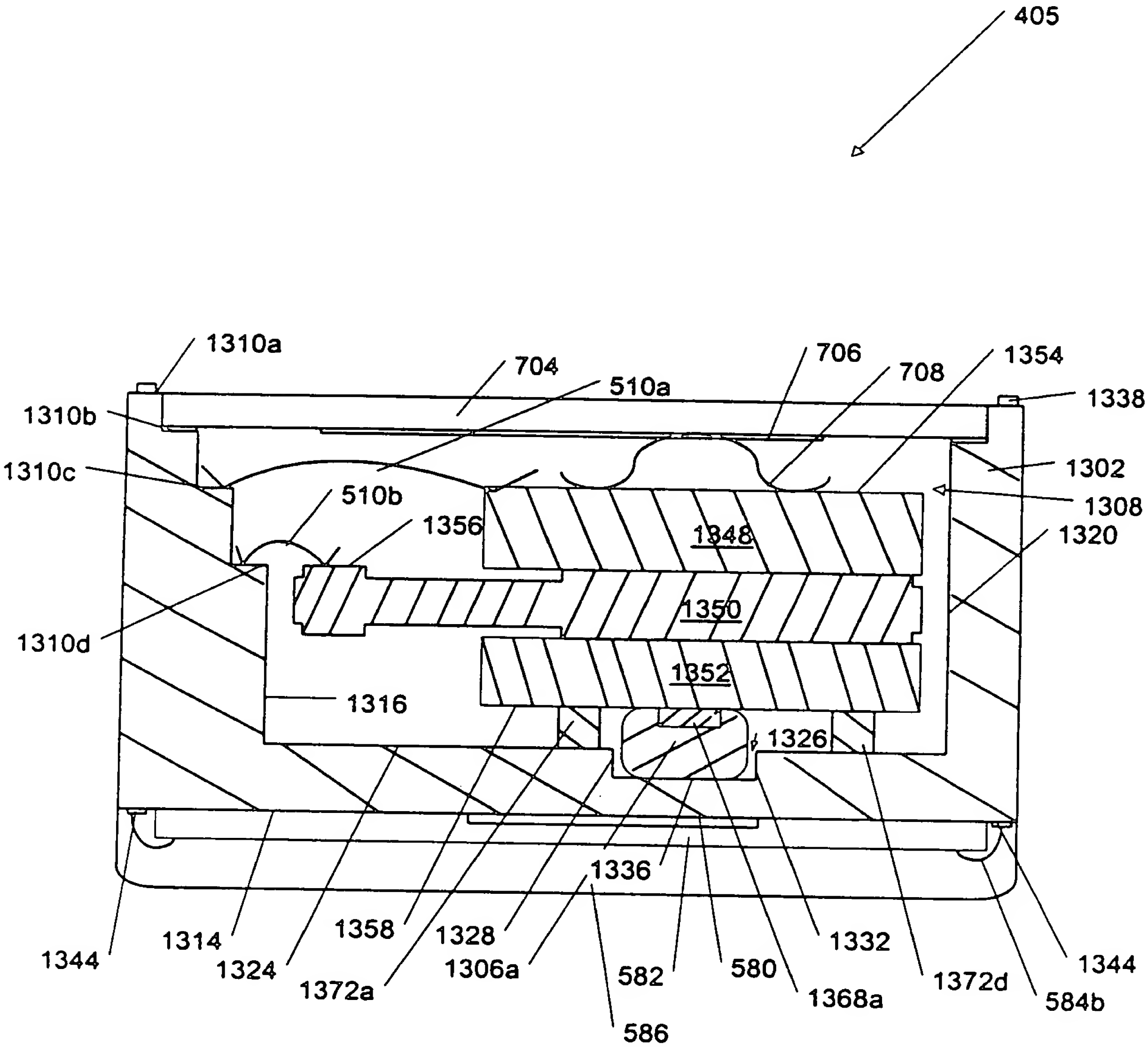

FIGURE 14

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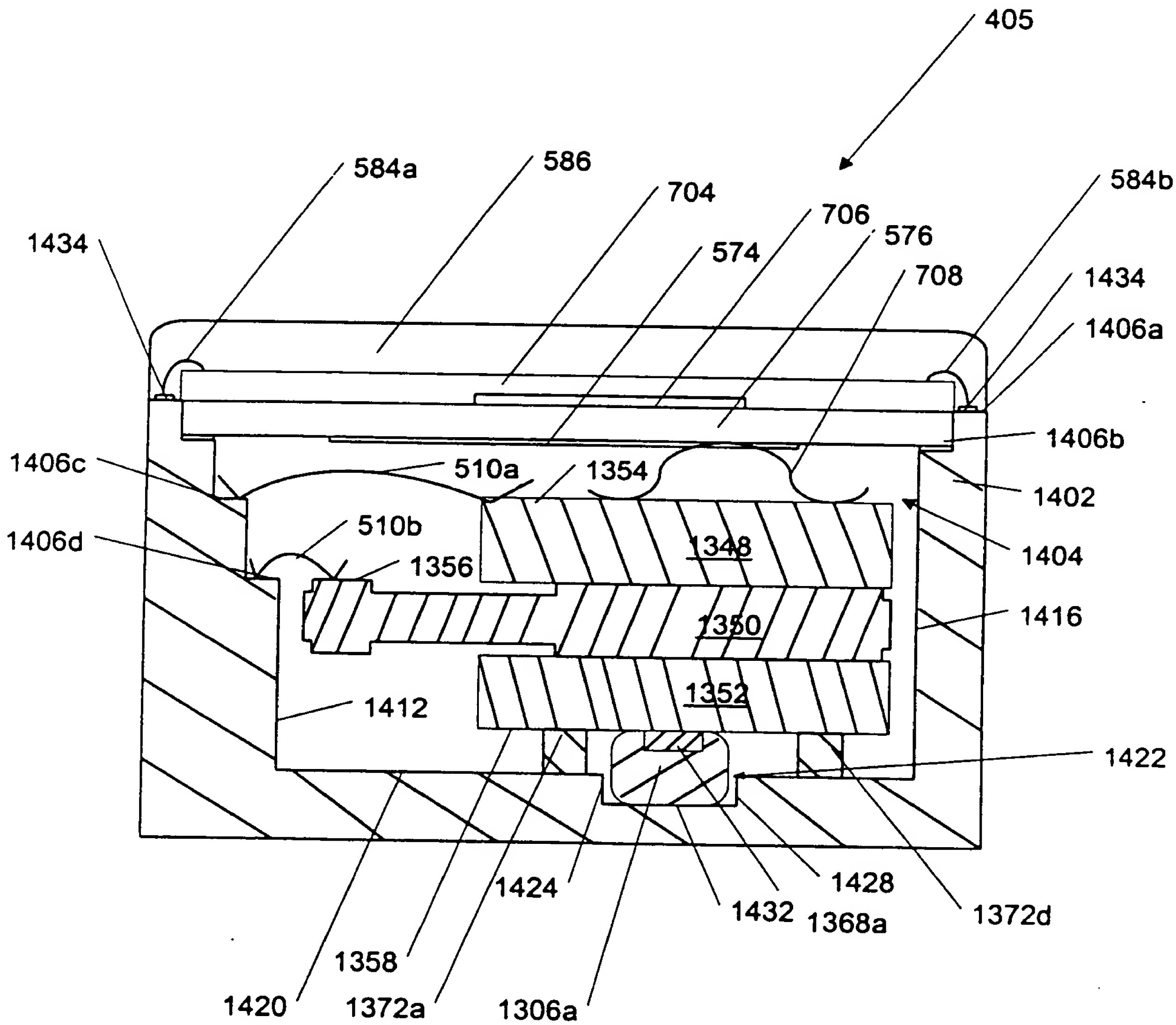
405
584a
586
704
706
576
574
708
584b
1434
1434
1406a
1406b
1406c
510a
1354
1402
1404
510b
1406d
1356
1348
1350
1416
1412
1352
1422
1424
1428
1432
1368a
1372d
1358
1420
1372a
1306a

FIGURE 15

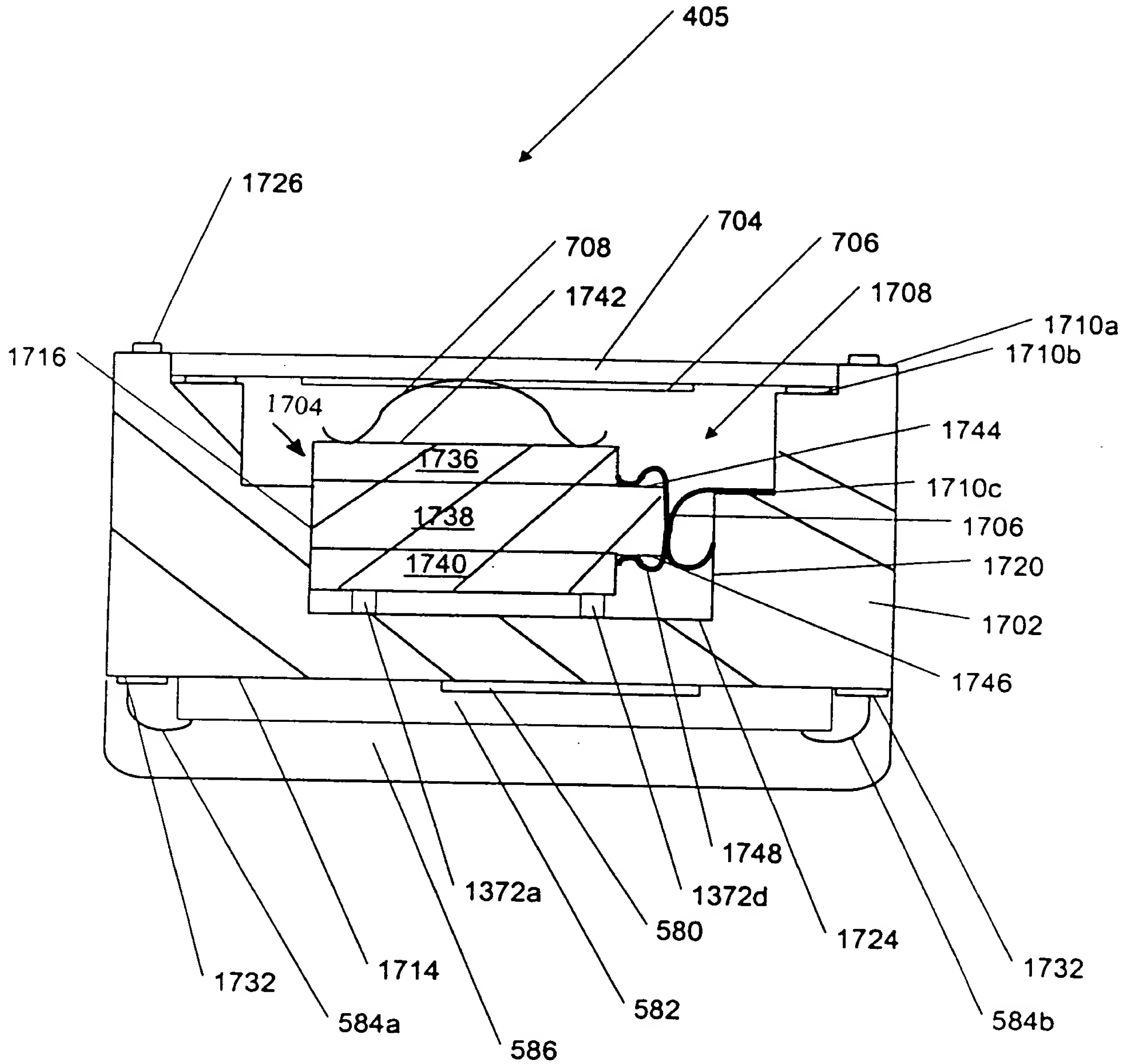
405
1726
708
704
706
1742
1708
1710a
1710b
1716
1704
1744
1736
1710c
1738
1706
1740
1720
1702
1746
1748
1372a
1372d
580
1724
1732
1714
1732
584a
582
584b
586

FIGURE 16A

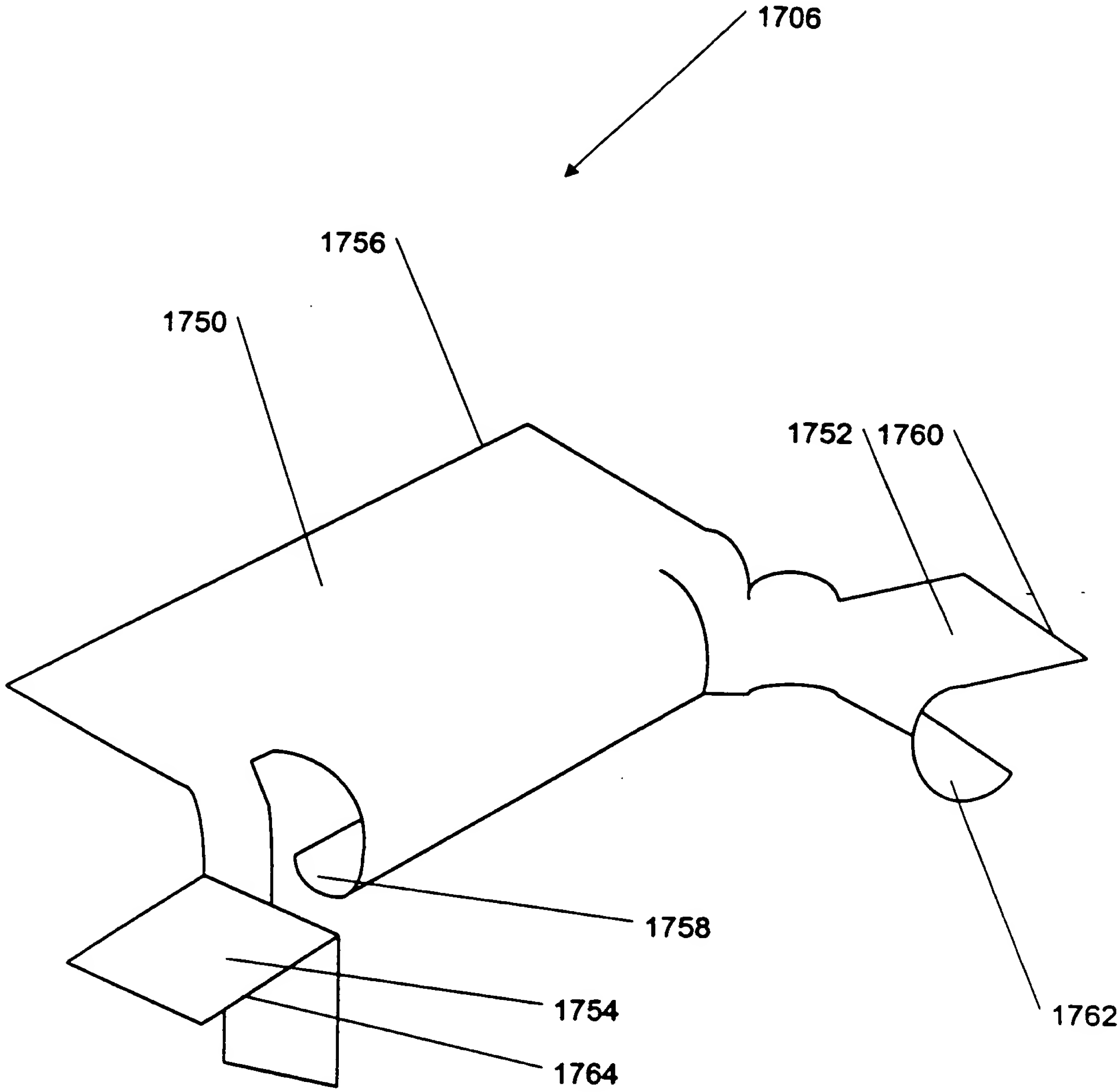

FIGURE 16B

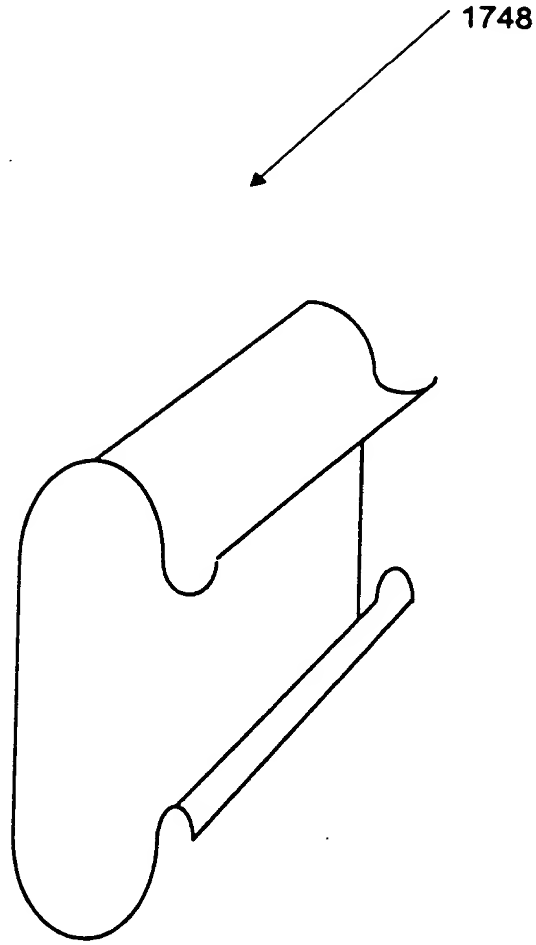

FIGURE 16C

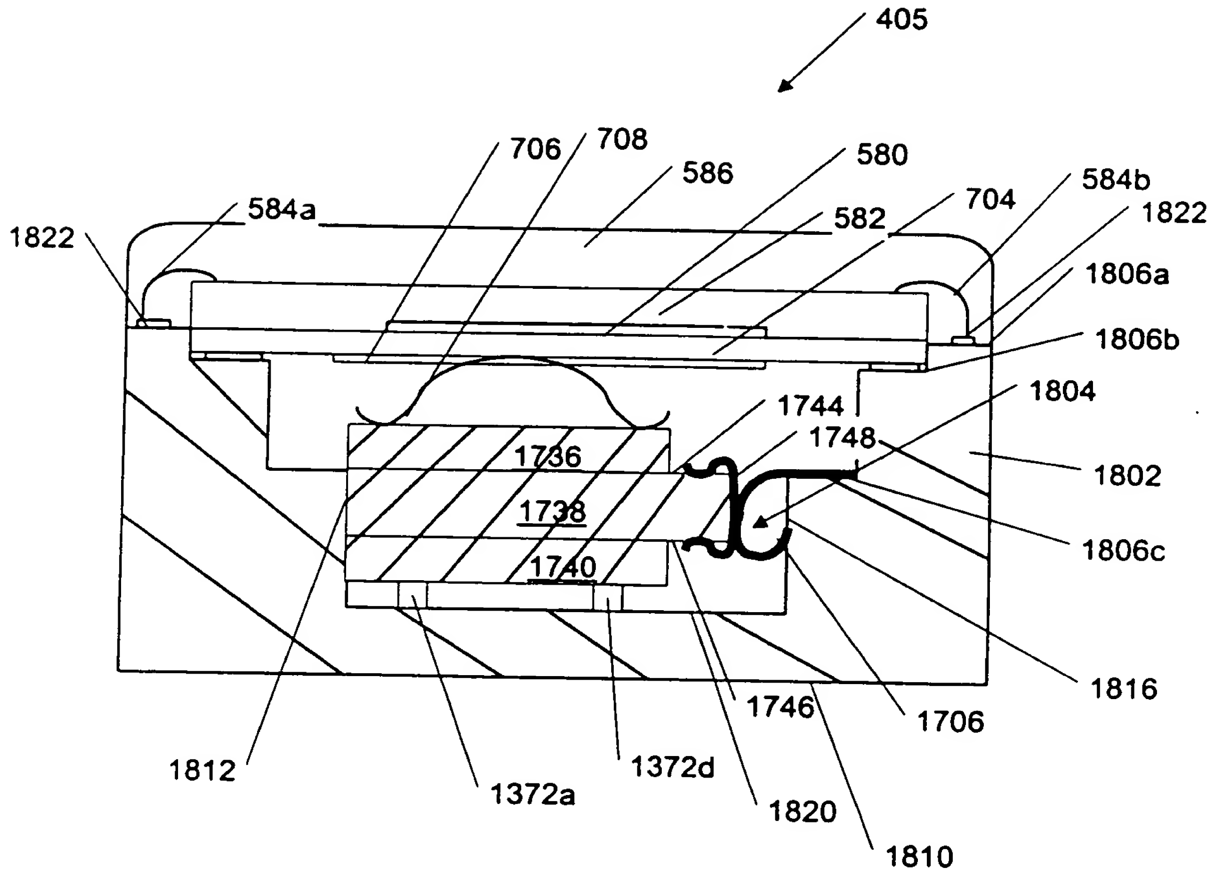
405
706
708
586
580
584a
582
704
584b
1822
1822
1806a
1806b
1804
1744
1748
1736
1738
1740
1802
1806c
1816
1706
1746
1812
1372a
1372d
1820
1810

FIGURE 17

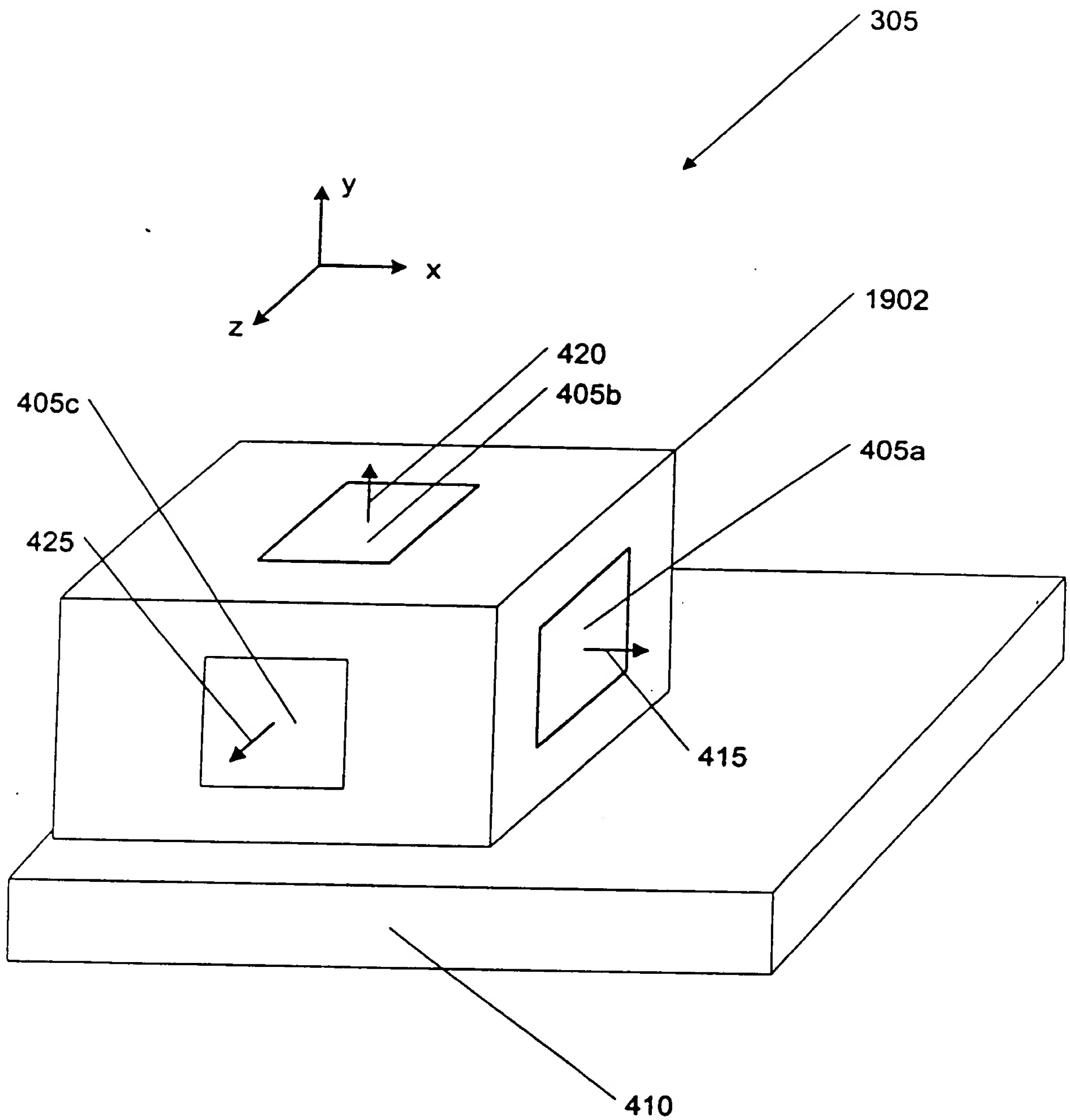

FIGURE 18

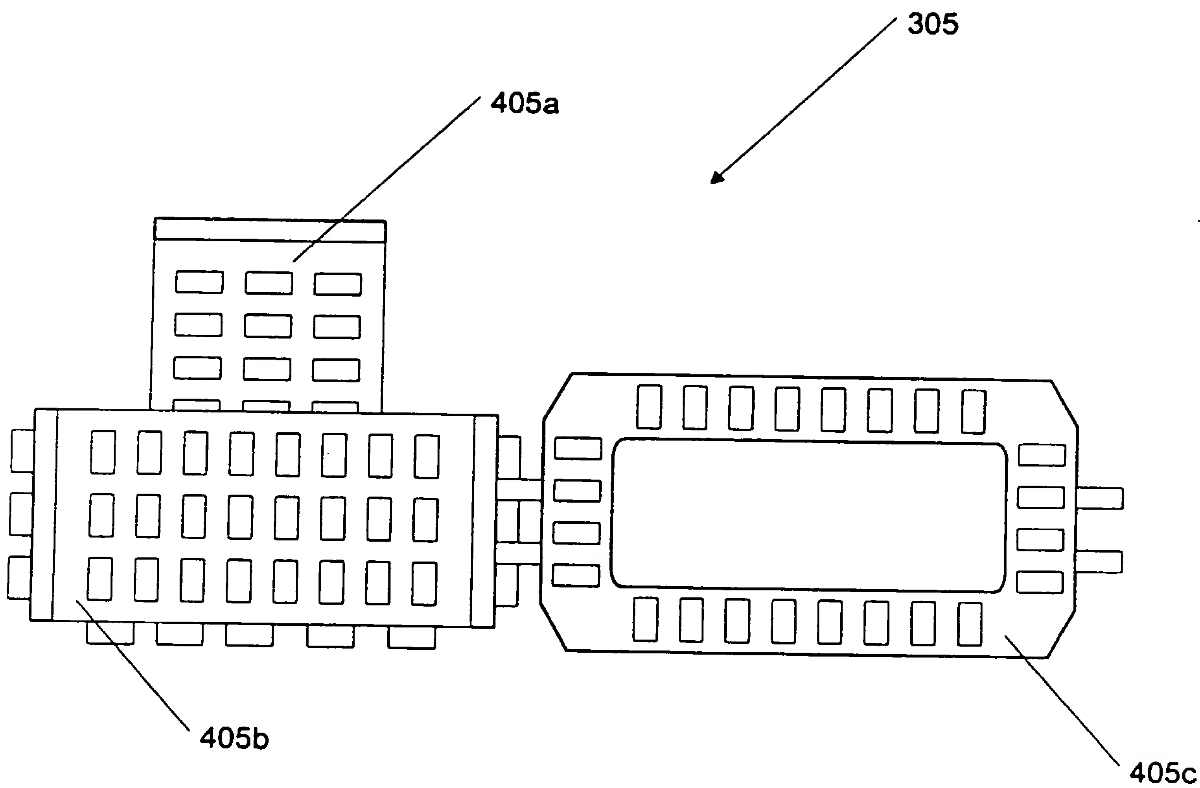

FIGURE 19

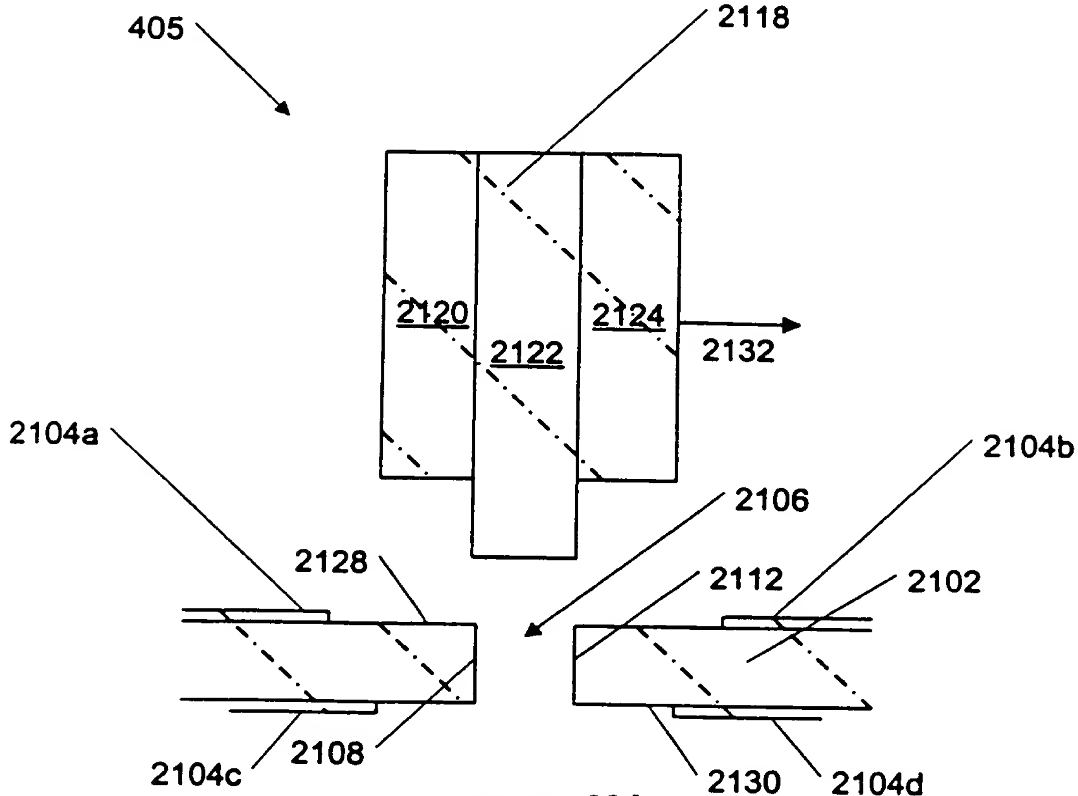

FIGURE 20A

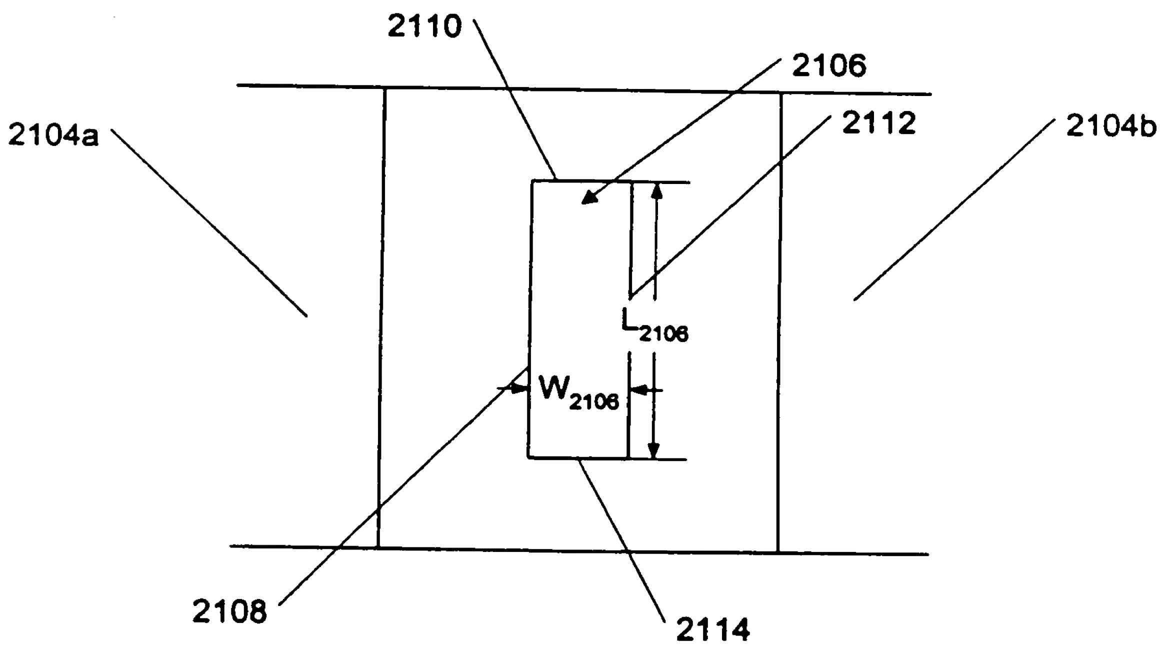

FIGURE 20B

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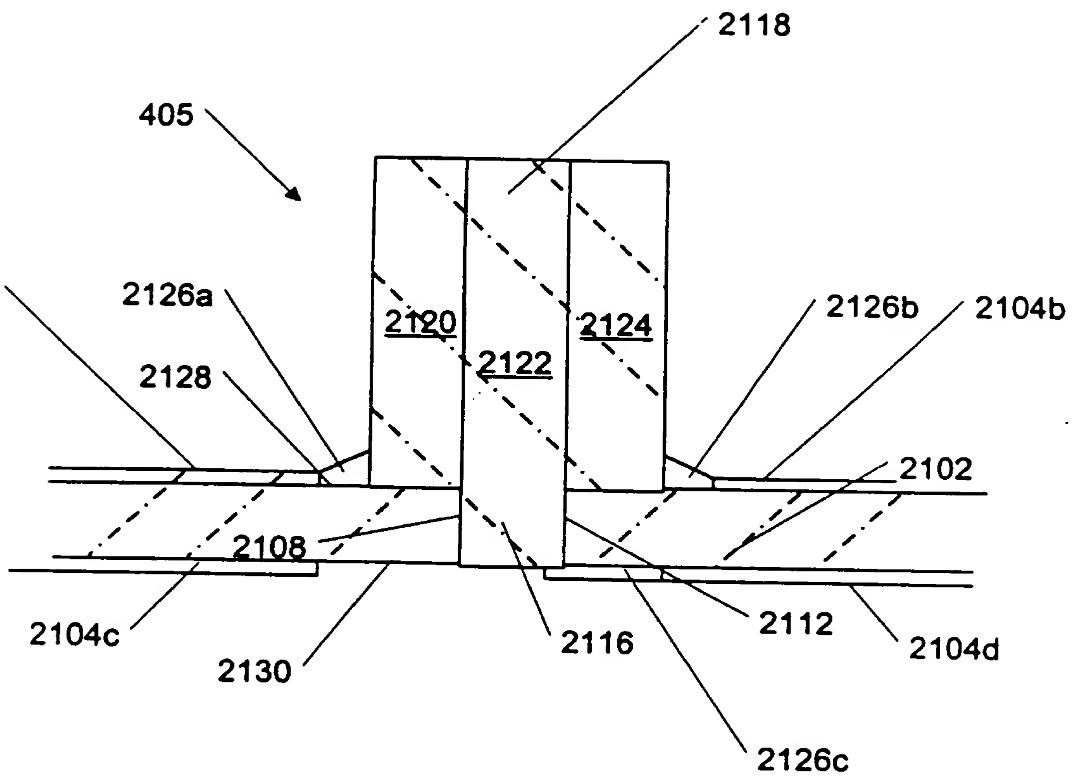
2118
405
2104a
2126a
2120
2122
2124
2126b
2104b
2128
2102
2108
2104c
2130
2116
2112
2104d
2126c

FIGURE 20C

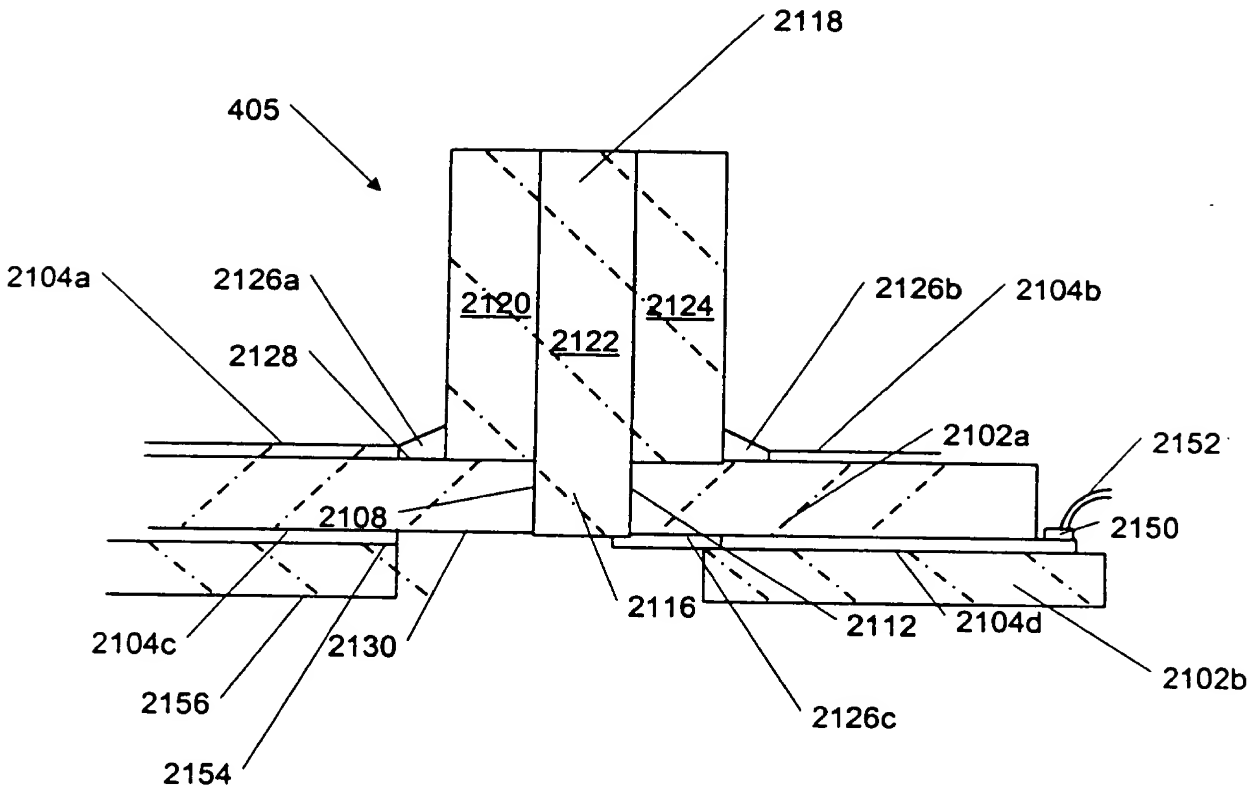
2118
405
2104a
2126a
2128
2120
2122
2124
2126b
2104b
2102a
2152
2108
2150
2104c
2130
2116
2112
2104d
2156
2102b
2126c
2154

FIGURE 20D

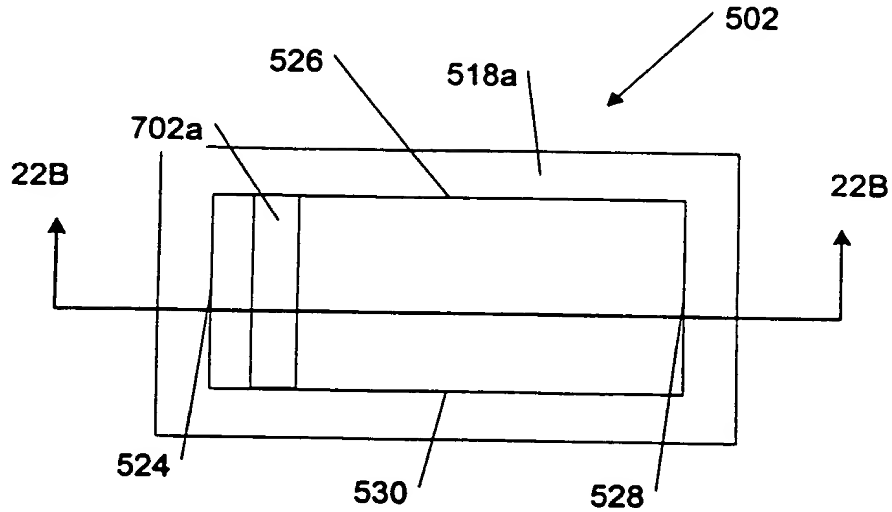

FIGURE 21A

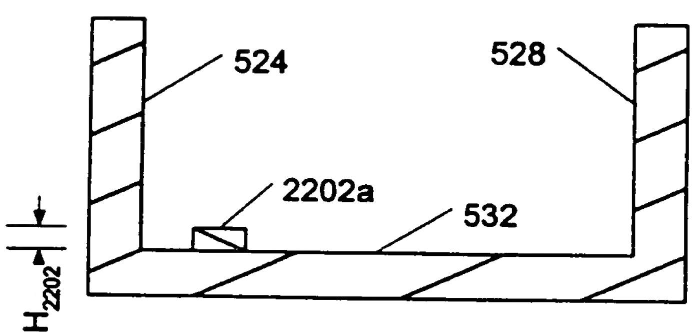

FIGURE 21B

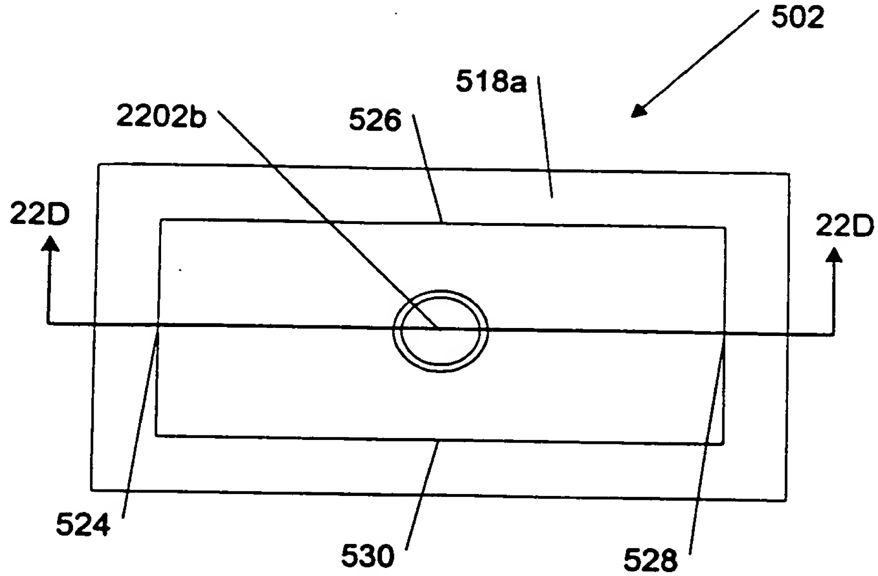

FIGURE 21C

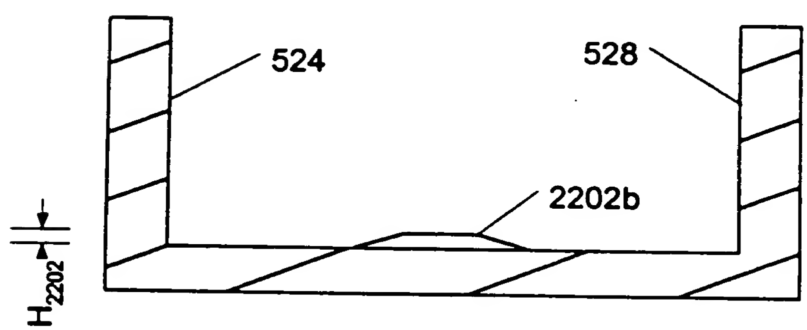

FIGURE 21D

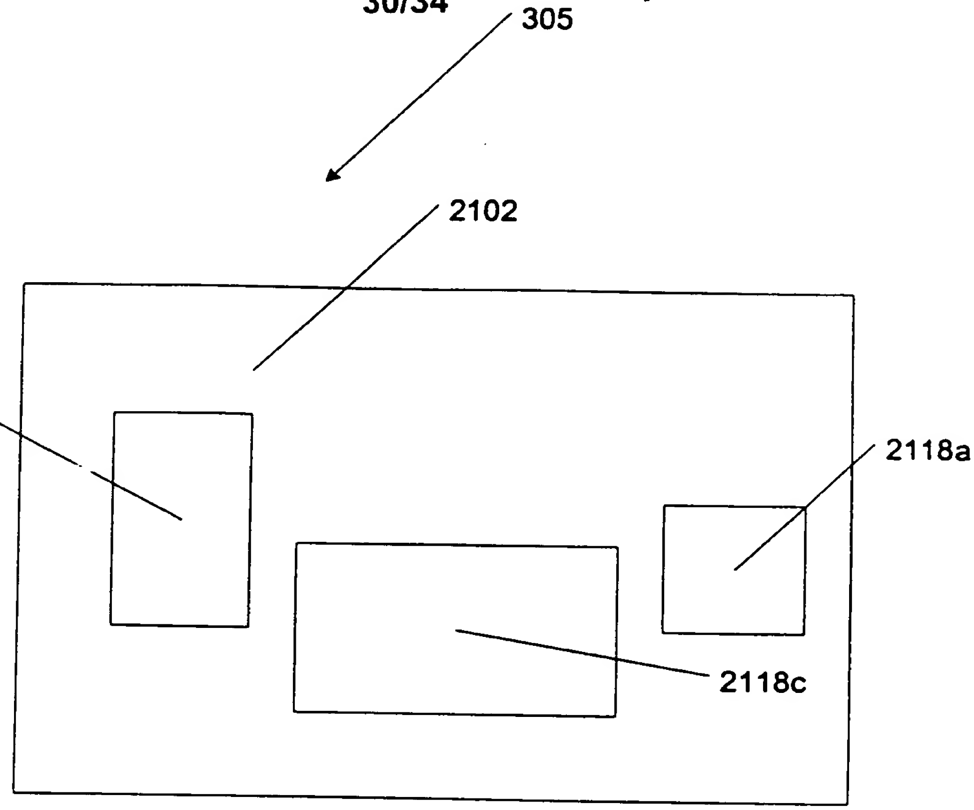

FIGURE 22A

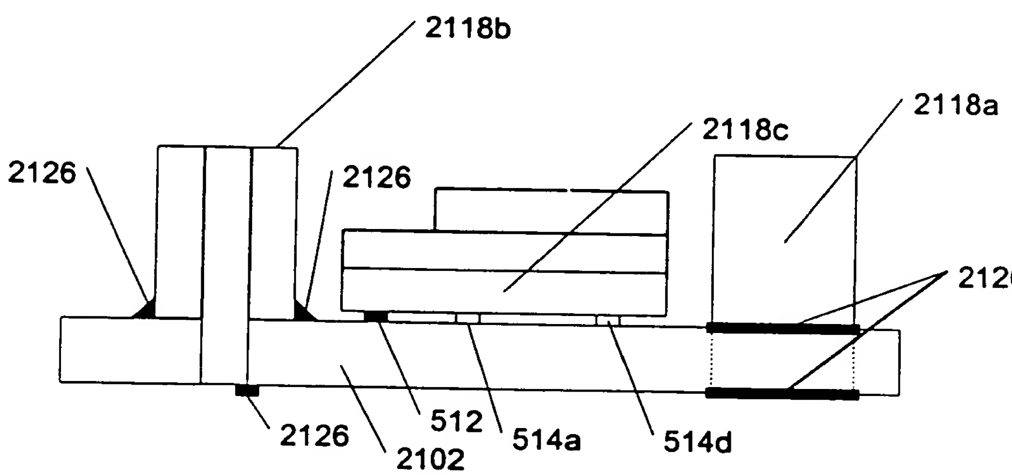

FIGURE 22B

PCT/US 00/07910
IPEA/US 15 MAR 2001

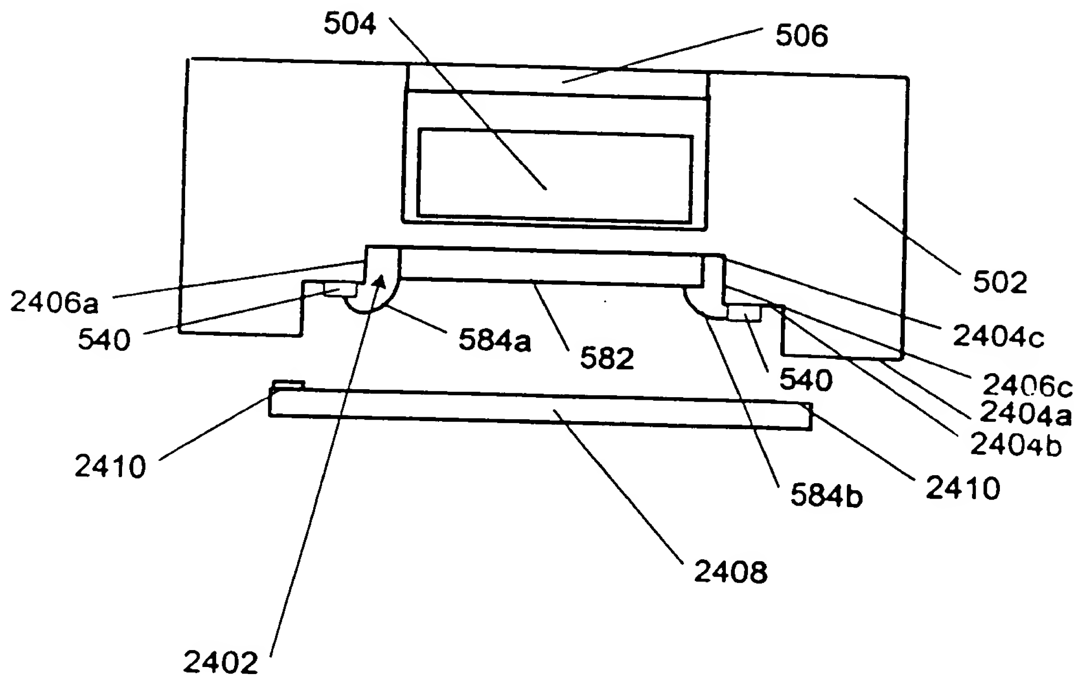

FIGURE 23

IPEA/US 15 MAR 2001

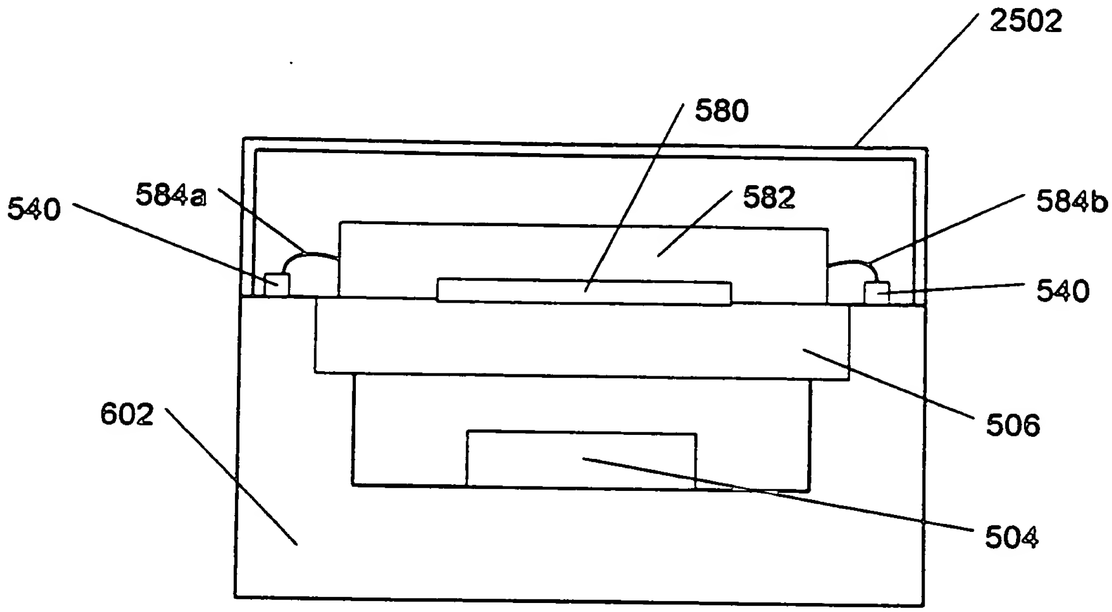

FIGURE 24A

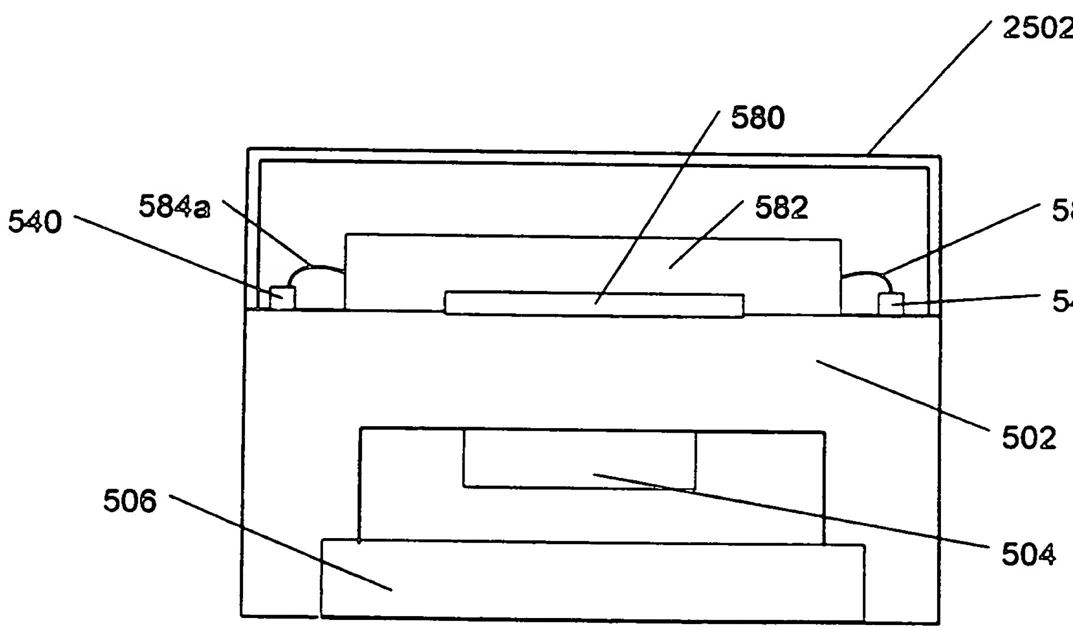

FIGURE 24B

AMENDED SHEET

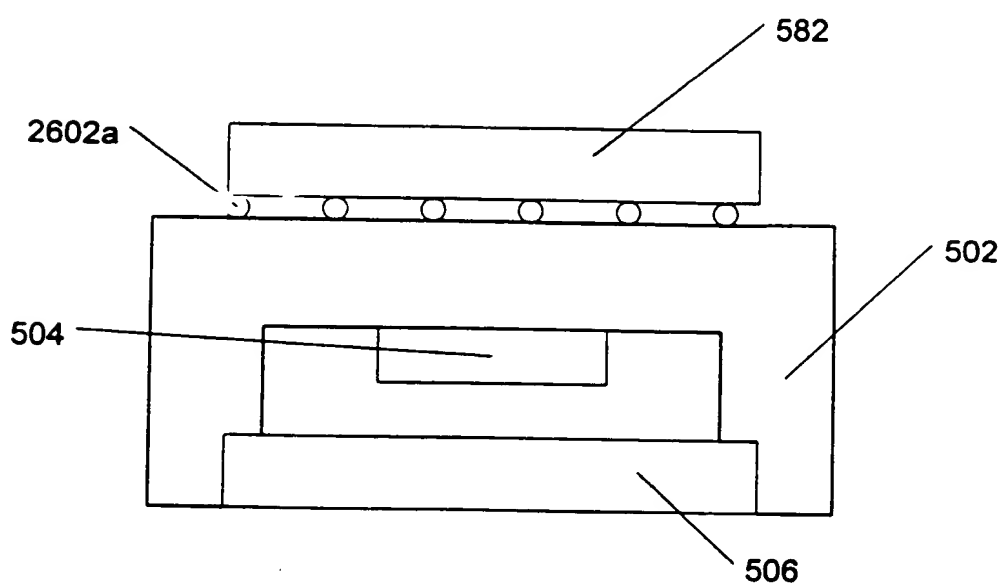

FIGURE 25A

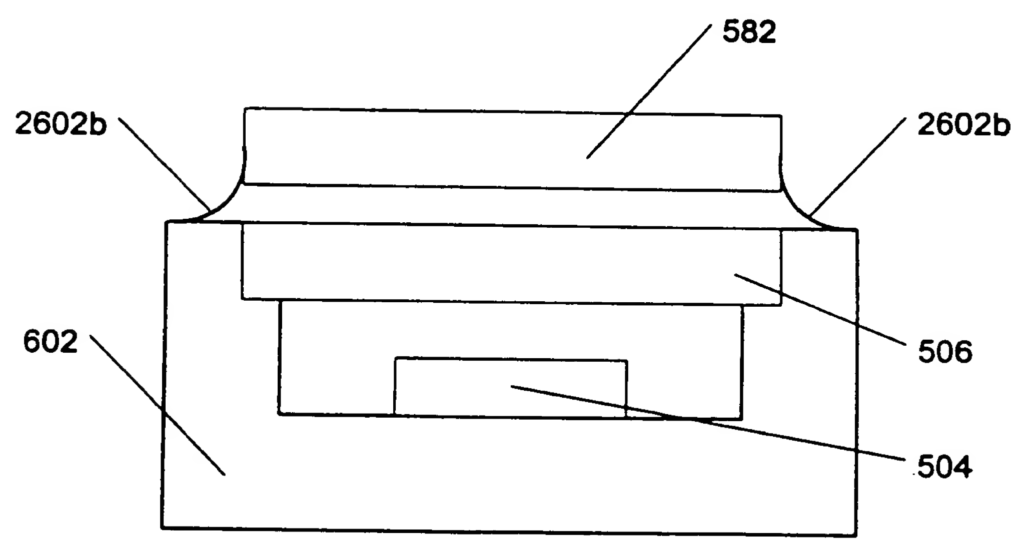

FIGURE 25B

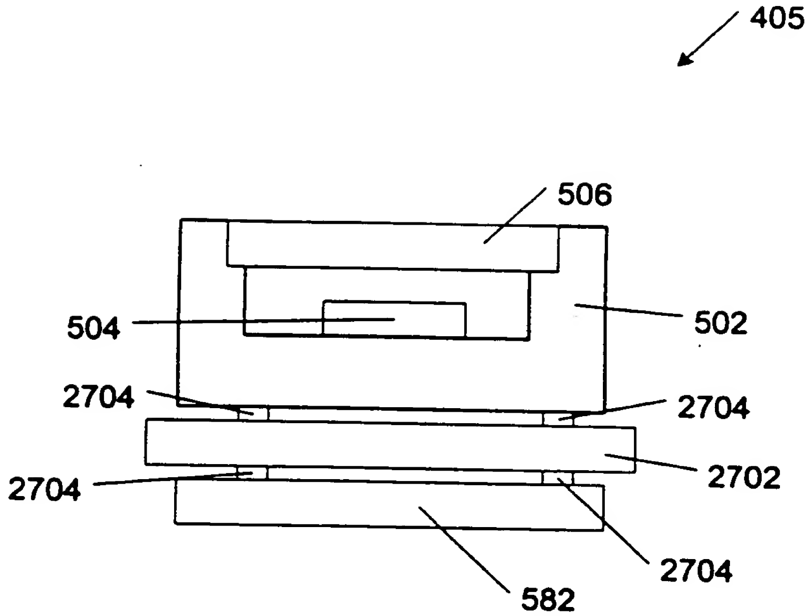

FIGURE 26A

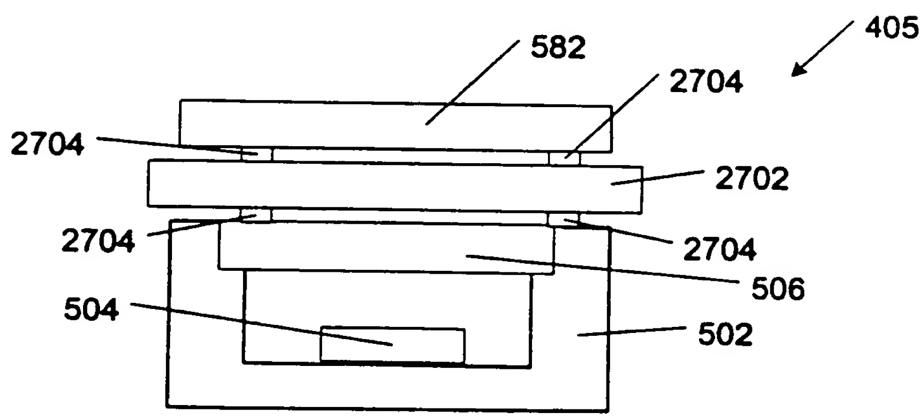

FIGURE 26B

AMENDED SHEET